Journal of SOIL and WATER CONSERVATION

VOLUME 2, No. 3, JULY 1947

CONTENTS

PROTECTING THE SOILS IN THE U.S.S.R.
S. S. Sobolev

HYDROLOGY OF WESTERN RANGES
E. N. Munns

THE QUANTITATIVE EVALUATION OF FACTORS IN WATER EROSION—A FIRST APPROXIMATION
G. W. Musgrave

SOIL MOISTURE RELATIONSHIPS ON RANGE LAND
Lester F. Lawhon

TECHNICAL STANDARDS AND A TECHNICAL GUIDE IN SOIL CONSERVATION WORK
Arnold J. Baur

PUBLISHED QUARTERLY BY
SOIL CONSERVATION SOCIETY OF AMERICA

SOIL CONSERVATION SOCIETY OF AMERICA

OFFICERS

HUGH H. BENNETT, *Founder*

RALPH H. MUSSER, *President*
926 Lexington Boulevard
Milwaukee 11, Wisconsin

LLOYD E. PARTAIN, *First Vice President*
201 Greenway Lane
Merion, Pennsylvania

R. G. HILL, *Treasurer*
717 Newton Street
Lansing, Michigan

KIRK FOX, *Second Vice President*
715 50th Street
Des Moines, Iowa

MELVILLE H. COHEE, *Secretary*
984 E. Circle Drive
Milwaukee, Wisconsin

COMMITTEES

Finance Committee

F. A. WIRT, *Chairman*

H. E. KLINGAMAN — DEWEY DISMUKE
C. H. DORNY — E. D. WARREN
R. G. HILL

Organization and Policy Committee

A. L. PATRICK, *Chairman*

C. H. BAILEY — PAUL GILLETT
H. H. BENNETT — LLOYD PARTAIN
JAY H. PRICE — JOHN S. BARNES
O. K. QUIVEY — KENNETH W. CHALMERS

Glossary Committee

E. M. SIMMONS, *Chairman*

A. M. HEDGE — PHILIP ALLAN
W. H. DANLEY — WARREN CHASE
E. A. NORTON — J. S. RENAUD
W. A. ROCKIE — W. B. KEMP
L. A. HAWKINS

National Program Committee

W. T. WHITE, *Chairman*

R. K. BLISS — WILLIAM H. DANLEY
J. C. DYKES — T. W. WEBB
DR. A. F. GUSTAFSON — PAULO P. P. DE MELO
WASHINGTON R. O'BRIEN — R. W. SCANLAN

Committee for Second Annual Meeting

GLADWIN E. YOUNG, *Chairman*

E. J. UTZ — WARREN HUFF
ROLANDO GUTIERREZ — T. S. BUIE
FLOYD MATHEWS — R. O. LEWIS
W. M. NIXON — R. E. MCARDLE
GLENN M. HORNER

Membership Committee

DALLAS E. PERFECT, *Chairman*

A. C. WATSON — VERY REV. GEORGE J. HILDNER
B. H. HOPKINS — JAMES HAMMETT
J. L. BOATMAN — GONZALO ANDRADE ALCOCER
WILLIAM X. HULL — L. A. HAWKINS
W. B. HAMPTON — J. L. SCHWENDIMAN

Publication and Editorial Committee

EDWARD H. GRAHAM, *Chairman*

FIRMAN E. BEAR — W. R. VAN DERSAL
H. L. JENKINS — CHARLES A. DAMBACH
KIRK FOX — B. W. ALLRED

JOURNAL OF SOIL AND WATER CONSERVATION

Published by the

SOIL CONSERVATION SOCIETY OF AMERICA

WALTER C. GUMBEL, *Editor*

LUNA B. LEOPOLD, *Associate Editor* BEN O. OSBORN, *Associate Editor*

VOLUME 2 JULY, 1947 NUMBER 3

CONTENTS

Editorial 122

Protecting the Soils in the U.S.S.R. 123

The Quantitative Evaluation of Factors in Water Erosion—A First Approximation 133

Hydrology of Western Ranges 139

Pictorial 145

Soil Moisture Relationships on Range Land 149

Technical Standards and a Technical Guide in Soil Conservation Work 153

From the President 156

Notes and Communications 157

Book Reviews 159

Recent Research Reviews 166

The Journal of Soil and Water Conservation is published quarterly by the Soil Conservation Society of America, 32nd Street and Elm Avenue, Baltimore 11, Maryland. Correspondence about manuscripts, books for review, and other editorial matters should be sent to the editor, Room 405, Bethlehem Building, Fairmont, West Virginia. The subscription price of the Journal of Soil and Water Conservation is $3.00 per year; single copies are 75 cents each. If a change in address is made, send the old address along with the new address to Melville H. Cohee, Secretary-Treasurer, Soil Conservation Society of America, 984 E. Circle Drive, Milwaukee, Wisconsin.

Entered as second-class matter in the Post Office at Baltimore, Md., August 28, 1946, under the Act of March 3, 1879.

EDITORIAL

SOIL CONSERVATION in recent years has attained the status of a science. At various times and at various stages along the route of its development, the term *soil conservation* has meant a physical condition of the soil, and lately, something more complex: the use of soil and water resources, jointly, in such a way as to maintain them indefinitely in a productive condition. There have been other definitions, most of which have been satisfactory for the occasion. Each man defines soil conservation as he sees it, and that is healthy.

Science, by simple definition, is a branch or department of systematized knowledge. What is known today about soil conservation meets this requirement.

Put it another way: The systematized knowledge we now have, supplemented by the findings of continuing research, will permit us to use soil and water resources in such a way that each acre can continue to produce, year after year, the maximum amounts of the things it is best suited to produce. It should be said immediately, however, that we do not yet have all the answers to soil conservation. Important problems remain unsolved for many areas. For example, farmers cannot always use their land for the things it is best suited to produce, because of economic considerations. Where compromises must be made, the conservation measures are less than 100 percent effective. On all fronts there is need for continuing research.

The knowledge we already have can be divided into three main categories: FACT, PRINCIPLE, AND METHOD. Among the *facts* can be listed all those in the realm of the biologic, agronomic, engineering, soil, hydrologic, and climatologic sciences having any pertinent bearing on soil and water conservation. There are many others.

The cardinal *principle* is, of course, the one developed years ago by Dr. Hugh H. Bennett, to the effect that soil conservation requires the use of each individual acre according to its individual capabilities and the treatment of each individual acre according to its individual needs. Another principle delineates soil, water, temperature, slope, and prevailing use as prime factors conditioning the rate and degree of erosion. Other principles, well known to soil conservationists, could also be enumerated.

Given the facts and the principles, the crucial element becomes the manner in which they are used and the purpose to which they are put, for soil conservation science is a purposeful science. Knowledge about soil conservation is not developed for the abstract value of the knowledge itself. That, at least, is the prevailing rule today. Instead, we seek and amass knowledge in this field for a practical purpose; to sustain indefinitely the productive capacity of soil and water resources while at the same time using them for maximum desirable production.

It is in the transition from knowledge of facts and principles to knowledge of *methods* and procedures for using the facts and principles that soil conservation science makes its greatest contribution to culture. It is precisely here that soil conservation science ceases to be merely an aggregation of more specialized sciences, and becomes a distinctive regime of knowledge in its own right.

To illustrate: What are the steps that need to be taken in applying soil conservation to a given area of land?

First, there is an analysis of the acre, to ascertain, as accurately as possible, the soil types, the expected volume of water to be handled, the length and degree of slope, the expected range of temperature, and the existing type of cover on the acre, if any.

Second, there is an evaluation of the importance of each of the above factors, singly and in relation to the others, from the standpoint of soil conservation.

Third, there is a determination, after full consideration of economic factors, of the most desirable, productive, sustained use to which the acre can safely be put.

Fourth, there is a determination of the specific combination of conservation measures, such as terracing, strip cropping, and improved rota-

(*Continued on page* 168)

Protecting the Soils in the U.S.S.R.

S. S. SOBOLEV

PROFESSOR-DOCTOR SOBOLEV, a member of the Dokuchaev Soil Institute, Moscow, is one of the leading soil conservation workers in the U.S.S.R. This paper—translated by Theodora Mills[1]—on the extent of soil erosion and on erosion control measures in Russia should be of interest to soil conservationists everywhere.

THE U.S.S.R. has been an agricultural country since ancient times. Its continental climate and dissected relief have contributed to the development of erosion. We find the first accounts of erosion in Herodotus, who wrote in the 5th century B.C. about the Muddy Scythian rivers in the cultivated portion of the Dnieper Basin. Ancient Russian documents, and other sources of the 12th to 16th centuries, contain references to gullies, eroded soils and dust storms. Erosion developed, chiefly near fortified cities where the farm population sought protection from attack by the Nomad-Pechenegs, Polovtsy and Tartars.

Soil Erosion Encouraged by Tax Reforms

The second period in the development of erosion began in 1718 with the reforms of Peter the Great. Peter I abolished the land taxes and replaced them by levies based on the number of serfs. This tax policy encouraged plowing of virgin land. Furthermore, by the time of the reforms of Peter I, serfdom, which put a stop to the mass migration of peasants to the free lands of the south and southeast, was definitely established in Russia. The tax reform and serfdom produced a characteristic distribution of cultivated land and of erosion, which goes with cultivation. Erosion developed rapidly in the over-populated central zone and in the northern zone—near Moscow, Suzdal, Vladimir, and Ryazan—but in the black soil zone, from which the Russian people were temporarily forced out by the Tartars, there were unpopulated virgin steppes, bearing the name "Dikoe Pole," (Wild Fields). The return of the people to the primordial Russian lands, the fertile black soil steppes, was artificially retarded by serfdom, which made it impossible for the peasants to migrate.

The third period of the development of erosion begins with 1861—the time of the liquidation of serfdom. To protect the interests of the landlords, the question of allotment of the land was decided differently for black soil and non-black soil provinces of Russia. In the non-black soil provinces, where the podzolic soils were rather unfertile and brought high returns only with the gratuitous labor of the serfs, the allotments to the liberated peasants were increased. The land was sold to the peasants at inflated prices. The part, which remained in the possession of the landlord, was only partly cultivated. A sizable part of this land was abandoned and grew up to forest. In the black soil provinces, where the fertile soil was valued highly and brought high returns with little labor, the peasants' plots were sharply reduced. Insufficient land forced the peasants to cultivate steep slopes and sandy soils which were not cultivated before the reform. This greatly contributed to the development of erosion.

Peasant Holdings Contributed to Erosion

Thus, the reform of 1861 had a double effect on the development of erosion—it resulted in intensive cultivation and the growth of particularly destructive processes of erosion in the black soil zone, and, at the same time, reduced cultivation and slowed the rate of erosion in the non-black soil zone. As a result of the reform,

[1]Mr. D. B. Krimgold, a member of the SCSA, edited the manuscript of the translation and converted all quantitative data into English units. For convenience of our readers, Mr. Kringold also converted the soil losses in the last column of Table 1 from cubic meters per hectar to the more familiar "tons per acre."

the center of agriculture has for a half a century (1861 to 1913) shifted to the black soil provinces. By the end of the period, according to the account of academician L. I. Prasolov, three quarters of all the land under cultivation was already found within the limits of the black soil zone, that is, in the provinces which up to this time were undeveloped and which bore the name "Wild Fields." Accordingly, the development of erosion shifted with agriculture. Peculiar to the period under discussion is the insignificant area under row crops (4.3% of the total sown area), which offer only slight protection from erosion. The greatest damage was caused by gully erosion to which the small peasant holdings contributed (see Fig. 1), but sheet erosion did not develop as seriously as in the United States where the proportion of row crops was considerably higher than in Russia.

The fourth period in the development of erosion, which began in 1917 after the October revolution, is radically different from the first three. The land was nationalized and the small holdings were combined into large, highly mechanized collective farms. In 1920, there were eight million wooden plows and other primitive implements on the peasant farms; in 1938, these implements were completely replaced by tractor-drawn plows. After collectivization, the boundaries of the tiny peasant plots, which concentrated water from melting snow and rainfall, disappeared. With these changes, the growth of gullies in a number of districts was retarded, and in some places ceased altogether. Deep plowing with tractor-drawn plows, correct crop rotations with perennial grasses, and improved practices—all contribute to the better growth of crops, which protect the soil from erosion, and to the formation of stable, crumbly soil structure. Surface runoff is decreased and the task of combatting destructive erosion is lightened. The planned, socialist economy of the U.S.S.R. permitted the introduction on a wide scale of a series of practical erosion control measures.

PHYSIOGRAPHIC CONDITIONS CONTRIBUTE TO EROSION

The U.S.S.R. is a tremendous country, stretching from the cold tundras on the shores

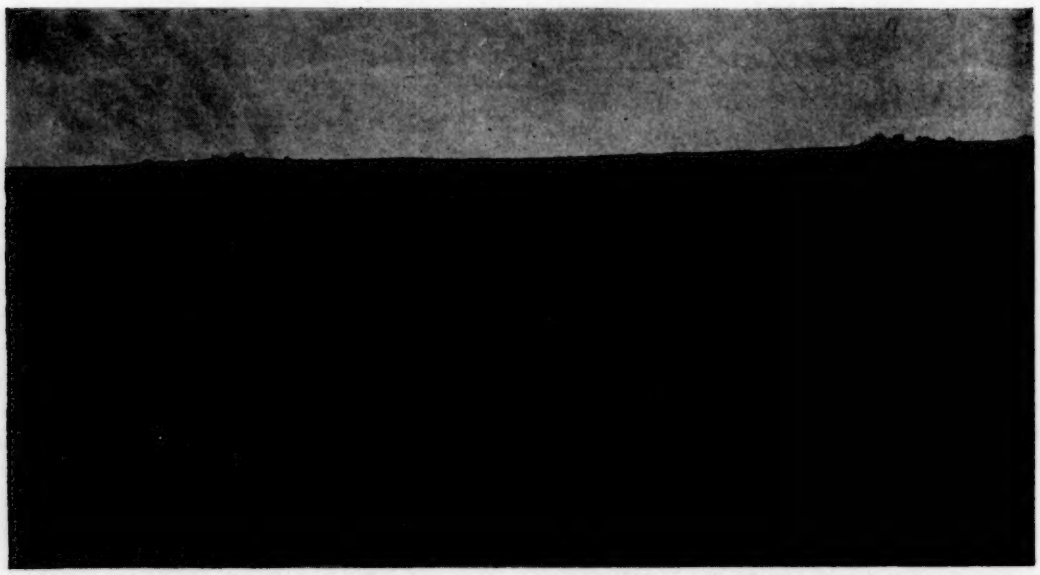


Figure 1.—Gullies formed along the boundaries of former peasant holdings.

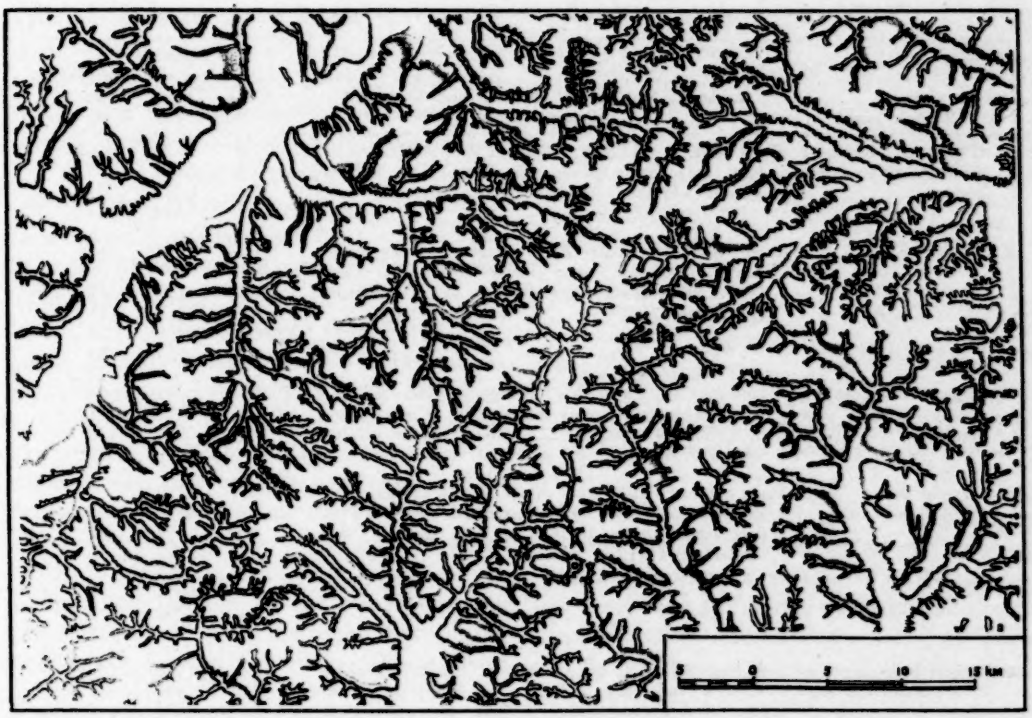


Figure 2.—The relief of Central Russian highland, dissected by ravines and gullies, is susceptible to erosion.

of the Arctic Ocean to the hot deserts of Central Asia, to the moist subtropics of the Black Sea area and to the Far East. The climatic conditions of the U.S.S.R. are quite varied, the agricultural belt is characterized by a climate of the continental type, which sharply distinguishes the U.S.S.R. from the countries of Western Europe and from a large part of the United States of America.

The winter in the U.S.S.R. is long and severe with the ground deeply frozen and with abundant snow cover. The rapid thawing of the snow in the spring and the heavy runoff of melting snow causes severe erosion and the growth of gullies. Erosion in the spring of the year is most widespread in the U.S.S.R. and causes the greatest damage. The particular condition of the surface layers of cultivated soils at the time of snow-melt contributes to erosion in the spring. The melting snow, which saturates the thawed out surface soil, is retained above the frozen layer and liquifies the soil. This is very conducive to erosion on dissected relief. Runoff from melting snow, which destroys the soil, accounts for about one-third of the annual precipitation. In the south and the southeast of the U.S.S.R., where the climate is continental, strong, dry, hot winds contribute to the development of wind erosion, dust storms and blowing of sandy and sandy loam soils. Wind erosion in the winter is widespread. During severe blizzards, the wind tears off the snow cover, destroys the soil and ruins winter crops over large areas. During such winters, snowdrifts mix with dust; the fields are not white but black; this is why winters, with severe wind erosion are called "black winters." Destructive cloudbursts, which erode the soil, are most frequent in the southwestern parts of the U.S.S.R., within the borders of the Ukraine and of Mol-

TABLE 1.—DISTRIBUTION AND INTENSITY OF EROSION ON SLOPES OF VARIOUS SHAPES

Item No.	Shape of Slope	Location, Soil, Crop, Observer and Date of Observation	Slope Percent	Distance from Divide Feet	Eroded[1] Material Tons/acre
1.	Convex becoming straight towards the bottom	Right bank of Oka Riv., village of Zharki, Tula prov.; light gray loamy forest soil. Rye. S. S. Sobolev. June 15, 1940.	1.8	328	—*
			3.5	1,148	8
			5.2	1,312	11
			5.2	1,640	14
2.	Convex	Right bank of Belaya Riv., village of Ryanzanovka, Bashkir, A.S.S.R.; gray loamy forest soil. Rye. G. A. Presnyakova under direction of S. S. Sobolev. September 15, 1941.	3.5	820	18
			5.2	984	21
			7.0	1,148	24
			7.9	1,312	43
			14.0	1,476	50
			16.7	1,640	58
3.	Straight becoming convex towards the bottom	Headwaters of Zusha Riv., village of Odinok, Orel prov.; dark gray loamy forest soil. Clean fallow. S. S. Sobolev. August 12, 1940. (Erosion resulted from a downpour of 2.6 in./hr.)	3.5	33	—*
			3.5	328	57
			5.2	951	132
4.	Straight	Right bank of Belaya Riv., village of Ryazanovka, Bashkir, A.S.S.R.; gray loamy forest soil. Rye. G. A. Presnyakova under direction of S. S. Sobolev. September 28, 1941.	0.9	2,710	—*
			2.6	2,871	3
			2.6	3,199	3
			1.8	3,527	1
			1.8	3,855	2
			3.5	4,839	8
			3.5	5,496	12
			3.5	5,824	10
5.	Convex becoming concave towards the bottom	Left bank of Usen Riv., village of Seushka, Bashkir, A.S.S.R.; calcareous and degraded loamy chernozem. Rye. S. S. Sobolev and R. S. Katz. September 1942.	2.6	328	—*
			7.0	492	3
			6.1	656	8
			14.0	984	8
			23.1	1,050	24
			21.3	1,116	28
			15.8	1,280	23
			10.5	1,444	20
			8.8	1,536	16
			5.2	1,732	11
6.	Convex-Concave	Left bank of Udryak Riv., village of Iena, Bashkir, A.S.S.R.; calcareous loamy chernozem. Clean fallow. G. A. Presnyakova under direction of S. S. Sobolev. June 21, 1941.	0.9-1.8	49-115	9
			3.5-5.2	262-722	36
			2.6-3.5	886-1,673	25
			0.9-1.8	2,001	7
			0.9	3,642	—*
7.	Terraced	Left bank of Usen Riv., village of Seushka, Bashkir, A.S.S.R.; calcareous chernozem on the convex part of the slope, leached and degraded chernozem on the flat surfaces of the terraces and on the concave alluvial toes. Rye. S. S. Sobolev and R. S. Katz. September 1942.	3.5	164	—*
			7.0	820	1
			5.2	984	11
			5.2	1,312	9
			3.5	1,640	7
			1.8	2,297	—*
			2.6	2,789	1
			1.8	3,609	—*
			2.6	3,937	1
			7.0	4,282	3
			10.5	4,544	6
			14.0	4,807	15
			19.4	4,938	21
			15.8	5,069	6
			5.2	5,266	—*

*Less than 0.3 of a ton per acre.

[1]The apparent specific gravity (volume-weight) of 1.3 was used in converting "cubic meters per hectare" to "tons per acre." (D. B. Krimgold)

davia; in parts of White Russia, in the Caucasus; in Transcaucasia (Georgia and the Krasnodar Region); and in the Far East. Also contributing to the development of erosion is the sharply dissected relief of central Russia (see Fig. 2) (the Volga, Privolzh, Volyno-Podolsk, Donets, Azov, Stravropol and other highlands). In the central and southern belts of the European part of U.S.S.R., about 50 million hectares (125 million acres), (approx. 35% of the arable land), are on slopes steeper than 2° (3.5%); about 16 million hectares (40 million acres) are on slopes steeper than 4° (7.0%); and about 6 million hectares (15 million acres) have slopes steeper than 6° (10.5%). The steepness of the slopes is not, however, the only factor in the development of erosion; the *shapes* of the slopes are also important. The several types of slopes can be grouped into three basic forms: convex, straight and concave. When combined, these elementary forms give compound forms: convex-concave, stepped and others. The rates of erosion on slopes of different forms (which are very important to know in devising different kinds of erosion control) are shown in Table 1 and schematically (Fig. 3).

The assembled data as well as the geographic distribution of eroded soils show the following: (1) The greatest destruction of soil is observed on the convex segments of slopes, where the steepness of the slope increases with the distance from the divide, and, at the same time, the volume of runoff water increases in proportion to the drainage area. (2) The least destruction is observed on the concave parts of the slopes (particularly on the slopes which approach a symmetrical profile). There the quantity of runoff water is increasing with the length of slope, but the steepness of the slope and the velocity of the water are decreasing. Progressing down, the slope erosion is diminished and replaced by deposition. (3) The process on straight slopes is the same as on convex slopes, but less pronounced. Here the volume of water increases down the slope but the steepness of the slope does not change. Therefore, the destructive

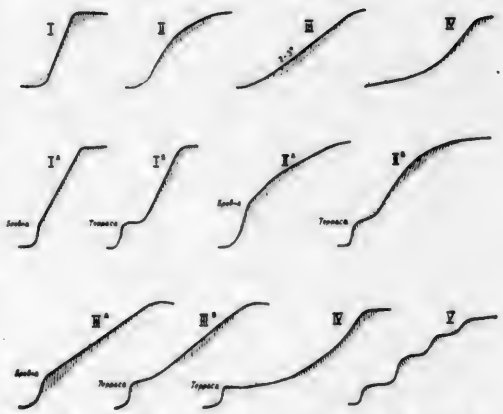


Figure 3.—Distribution of erosion (hatched) and deposition (dotted) on slopes of various forms.

force of the runoff water grows only gradually in proportion to the increase of the drainage area, that is, in proportion to the volume of runoff water. (4) In the case of compound slopes: stepped, concave-convex and others (see Table 1), the steepness and length of the slope plays a less important role than the sequence of the adjoining segments. Thus (Table 1, Example 7), if a slope of 11° (19%) is changed further down to a slope of 9° (16%), then, there is strong washing on the 11° section. But on the 9° slope, in spite of the fact that the slope is still quite steep, erosion decreases more than three times and deposition of silt is observed (in the particular instance, there was deposited 6.7 cubic meters of silt per hectare). Where the slope changes from 8° (14%) to 11° (19%) erosion proceeds on both parts of the slope, increasing in a downward direction.

In the development of the processes of wind erosion in the U.S.S.R., the following principles are recognized: (1) While water erosion, being governed by the force of gravity, increases downwards, wind erosion, governed by the laws of movement of vast air masses, becomes stronger with altitude of the locality (in relation to the general relief) and with the decrease of friction (see Table 2). With the same soil cover, valley floors and depressions suffer the least while prominent relief features, such as

TABLE 2.—SURFACE WIND VELOCITIES ON A SLOPE OF A RIVER VALLEY EXPRESSED IN PERCENT OF CORRESPONDING VELOCITIES ON THE RIDGE

(Anemometric observations were carried out in the summer of 1943 by R. S. Katz, N. Ya. Kirillov, A. V. Kozlova and V. P. Kozlov under the direction and with the participation of S. S. Sobolev. The study was made on a 25% slope of the right bank of the Senshka River, Bashkir, U.S.S.R.)

Station Number	Description of Stations: Part of Relief	Description of Stations: Height above River	Height above Herbaceous Cover: 40 Inches: Wind Southerly 27.4 mi/hr	40 Inches: Direction and Southwesterly 10 mi/hr	40 Inches: Velocity Westerly 7.4 mi/hr	6 Inches: Wind Southerly 21.2 mi/hr	6 Inches: Direction and Southwesterly 7.6 mi/hr	6 Inches: Velocity Westerly 5.4 mi/hr
		Feet	Percent	Percent	Percent	Percent	Percent	Percent
10	Flood Plains	5	44	34	0(calm)	50	33	0(calm)
14	Slope of bank	79	68	70	65	61	63	63
16	Slope of bank	171	71	77	77	76	67	62
18	River Terrace	256	67	62	61	68	66	60
19	Ridge	269	100	100	100	100	100	100

"breaks," ledges of terraces and other so-called windswept slopes, which offer greatest resistance to "ground" air movement, suffer the most. (2) Just as with water born erosion, the damage from wind erosion is greatest on convex slopes, less severe on straight slopes, and least of all on concave slopes, on which wind erosion is usually replaced by deposition. As distinct from water erosion, wind erosion damage is most pronounced on the upper parts of slopes at the ridge. (3) The more abrupt the break of a cultivated, windswept slope, the more pronounced is wind erosion. (4) Gradual changes in the rate of wind erosion are associated with gradual changes in the degree of slope; a sharp change in the steepness of the slope is accompanied by a sharp change in the rate of wind erosion. Therefore, the steeper the windswept slope, the more severely the soil is destroyed by wind erosion.

The various maps prepared for the European part of U.S.S.R., include maps of the distribution and rate of water and wind erosion processes, a map of the distribution of eroded soils, maps of density of gullies and ravines, maps of the depths of local erosion bases,[1] and maps of shape and steepness of slopes (by S. S. Sobolev).

These maps facilitate correct planning of erosion control measures.

DAMAGE INFLICTED BY EROSION TO LAND RESOURCES

The enumerated conditions contributing to the development of erosion and the long history of agriculture account for the existence in the U.S.S.R. of appreciable areas destroyed by erosion and for active erosion on large areas.

In 1934, the gullied area in the U.S.S.R. amounted to 4,489,000 hectares (11 million acres). The annual growth of gullies, of adjoining land taken out of cultivation, and of land covered with debris from gullies constituted approximately 2% of the total gullied area. The annual loss of land (arable, meadows and pastures) from gully erosion, prior to 1917, was thus approximately 90 thousand hectares (1/5 million acres). We have already mentioned that, because of the dissected relief, 50 million hectares (125 million acres), or about 35% of the arable plains of European U.S.S.R., have slopes steeper than 2° (3.5%); of this total approximately 30 million hectares (74 million acres) have suffered to some extent from erosion; about 11 of the 30 million hec-

[1] "Depth of local bases of erosion" is a literal translation. It may mean depth of soil removed by erosion. D. B. Krimgold.

tares (27 of the 74 million acres) have already been severely eroded and to a noticeable degree have lost their fertility (parts of these regions in central and northern Russia have become overgrown with woods). These severely eroded soils are found in strips along the banks of ravines and of river valleys. In the southern portion of the Chernozem, it took something like 100-150 years to erode strips about 130-170 meters (425-500 feet) wide along ravines, that is, roughly speaking, erosion was progressing at a rate of about one meter (3.3 feet) per year (or 0.5 m. for each side of the valley or ravine), *i.e.*, about 1% of the total area of eroded soils. According to these approximate calculations, about 100 thousand hectares (247 thousand acres) of fertile, arable land in European Russia are annually transformed into less fertile or even unsuitable waste land.

For wind erosion, we find figures on the destruction of sandy and sandy loam soils which are most susceptible to wind erosion. According to the calculations of academician L. I. Prasolov, there are in the U.S.S.R., 195,570 thousand hectares (480 million acres) of such light-textured soils. Incomplete data as of 1937, indicate that 14,623 thousand hectares (35 million acres) of these soils were destroyed by wind erosion; the annual increase constituted on the average about 1% of the total area of untreated sandy land. Therefore, the annual loss of arable land and pastures from wind erosion prior to 1917 constituted approximately 146 thousand hectares (360 thousand acres). Wind erosion has been especially destructive in the Asiatic part of the U.S.S.R.—the cattle country of Kazakhstan and the deserts of Central Asia. Here, out of 13.1 million hectares (32.4 million acres) of sandy and sandy loam soils, wind erosion has destroyed 7.4 million hectares (18.3 million acres), or about 57%.

These are the results of farming and grazing practices carried out over many centuries without regard of the importance of safeguarding the soil. This is what our generation inherited.

Recently, in the years of the War for the Fatherland (World War II), problems of erosion control have been seriously complicated by the rise of a new type of erosion—*war erosion*. The heaviest battles with the Germans were fought in districts with the most destructive erosion, where every break in the soil cover frequently leads to the development and growth of gullies. Trenches, communication passages and other fortifications and military roads, involve destruction of vegetative cover, thus facilitating erosion. In many instances, these structures divert and concentrate surface runoff and small streams of melting snow into large streams. Soil erosion and particularly gully formation are thereby sharply increased.

PRINCIPLES OF EROSION CONTROL IN THE U.S.S.R.

The peculiarities of the physiographic conditions and also the existence of large mechanized collective and state farms call for a special system of erosion prevention and of regulation of surface runoff. In the U.S.S.R., the following measures have found the widest application: (1) Show retention and regulation of the runoff from melting snow. (2) Improvement of the structure and increasing erosion resistance of the soils by introducing correct crop rotations with perennial grasses and improved farming methods. Special soil protecting rotations are introduced on areas most exposed to water and wind erosion. (3) Shelter belts. (4) A series of other measures, involving improved farming practices.

The control of snow drifting and of snow melting, and, also, the retention of water on the land are very widespread and effective methods of preventing erosion. Ever since tht middle of the last century, snow retention has been practiced with mobile snow fences (B. Titov, 1868). This is the most effective method but there are several other ways. Screens of corn ("Kherson fallow"), of sunflower ("Voronezh fallow") and of high stubble; scattering bundles of straw; furrowing the snow with special plows; rolling; ridging and other methods—all yield good results and are inexpensive.

On winter crops, screens are used, consisting of plants spaced so that the openings amount to 50%. Such screens distribute the snow evenly and contribute to better wintering of crops. On plowed fallow land, solid screens are placed on the contour. Such screens cause the snow to drift along the contour. The drifted snow acts like a dike or terrace; it retards the flow of water from melting snow and controls erosion. Extensive use is made of screens of sunflowers planted in double rows on summer fallow 3.6 meters (11.8 feet) apart (the width of a tractor cultivator). Winter crops are planted in any direction—parallel, across, or diagonal to these "screens." The sunflowers are planted in the summer which does not allow enough time for their stalks to become stiff enough to hinder the sowing of winter crops. The practice of interplanting colza or rape with winter grains for the retention of snow dates back to the end of the last century (I. Brounov, P. Kostychev). These spring plants develop luxuriously during the fall, but, do not produce seeds before frost. They do not, therefore, infest the crop, but provide a uniform distribution of snow.

RETENTION OF SNOW AIDS EROSION CONTROL

Snow retention protects the soil from wind erosion; protects crops from winter kill; decreases the depth of freezing; raises the permeability of the soil; decreases surface runoff and increases soil moisture. Therefore, snow retention, which is one of the powerful means of controlling erosion, also, noticeably raises the yield of agricultural crops (Table 3). Snow retention is particularly effective in areas with dissected relief and in localities with strong winter winds.

Runoff from melting snow is regulated in two ways; by utilizing the snow itself and by creating obstructions on the surface of the soil.

In utilizing the snow itself, the objective is to induce uneven melting so that the thinner mantle between the snow ridges will melt earlier and the soil will thaw out sooner and will absorb some of the water, while the contour ridges of unmelted snow will intercept the runoff. Melting is hastened by sprinkling ashes and earth, or by loosening or scraping with snow plows. Mulching of the snow with straw, controlled drifting by means of open and solid screens, ridging with special implements and other means are used to retard melting. By alternating slow melting with rapid melting strips, the snow is made to soak into the soil and destructive erosion is avoided. Control of runoff from snow-melt and from rainfall by surface obstructions, created by suitable tillage and by terracing, has been practiced since the middle of the 19th century. Contour cultivation and contour ridging (terracing), basin listing and check-rowing have been employed by a series of experimenters (Shishka, 1840; Shishkin, 1873; Yankov, 1891; Dokuchaev, 1894; Shalabanov, 1903; and others). Their studies showed that these methods are very effective and often increase the supply of available moisture in the ground 2 to 2½ times, while at the same time controlling erosion.

TABLE 3.—PERCENT INCREASE IN YIELDS FROM SNOW RETENTION ACCORDING TO DATA OF EXPERIMENTAL INSTITUTIONS. (N. S. Sokolov, 1935; I. I. Tumatov, 1940)

Station	Winter Wheat		Spring Wheat		Sunflowers	
	Years of Record	Increase in Yield Percent	Years of Record	Increase in Yield Percent	Percent Years of Record	Increase in Yield Percent
Saratov	9	39	12	34	12	43
Krasnokut	4	86	8	36	....	....
Kamyshinsk	3	153	....	....	....	....
Novoannenkov	2	30	....	....	....	....
Bezenchuks	4	99	....	....	....	....
Balashov	6	33	....	....	....	....
Buzuluk	2	24	....	....	....	....
Kuibyshev	8	45	....	....	....	....
Boguchar	3	6				

These methods have been perfected and are being applied under conditions of mechanized farming of the collective and state farms.

EMPHASIS IS PLACED ON EROSION RESISTANT SOIL AGGREGATES

Very great significance is attached in the U.S.S.R. to the improvement of the structure of the soil and increasing the resistance to erosion. Dokuchaev, Kostychev and, later, Williams set out the sound principles concerning the role of stable, crumbly structure of the soil in controlling erosion and obtaining consistently high crop yields. Correct crop rotation with perennial grasses, along with good tillage practices, are of great importance in creating such soil structure. Researches have shown that under conditions in the U.S.S.R. perennial grasses in the second year of growth (that is, with one field in rotation) increase the number of erosion resistant soil aggregates by 30-50% and in the third year (that is, with two fields of grasses in rotation) by 50-70%. Crop rotation with 1 or 2 fields of perennial grasses are now being introduced everywhere in the U.S.S.R.; they are already being followed on an appreciable area. Special soil conserving crop rotations, with 3 and 4 fields of perennial grasses, are used on areas with severe water and wind erosion. In arid regions the rotations include 5 fields of perennial grasses and bare fallow and inter-tilled crops are largely eliminated.

Shelter belts, for tempering the climate of arid regions, for protecting agricultural crops from black blizzards (dust storms) and droughts and, also, for controlling water erosion, by regulating the distribution and melting of snow, have been used on territories of the U.S.S.R. since the beginning of the 19th century. In 1809, Lomikrovskii began the first experiments on shelter belts. In 1837, he published a book, in which he set forth a sound system of woodland farming. Before the war (1932-1937), about 68 thousand hectares (168 thousand acres) of shelterbelts were planted annually on cultivated land in the U.S.S.R. Over 26 thousand hectares (64 thousand acres) of sandy soils and about 23 thousand hectares

Figure 4.—Trees, planted along gullies, accumulate snowdrifts and prevent the runoff from melted snow and rain from reaching the gullies, thus contributing to rapid stabilization.

(57 thousand acres) of gullies were being stabilized and planted to trees annually. The amount of work carried out annually in the U.S.S.R. has exceeded many times the amount of ameliorative work of pre-revolutionary Russia. For the protection of cultivated land from wind erosion and drought, shelter belts of 7-8 rows in width are used; they are of the open type so that the wind does not flow around them and the flow of air through them does not exceed 50%. Such belts decrease the velocity of wind by 70% at a distance 10 times the height of the trees and by 50% at a distance 20 times the height of the belt. The average reduction in wind velocity within a 100-hectare area, surrounded on all four sides by a belt 8 rows wide and 15-17 meters (49-56 feet) in height, ranges from 0% for a velocity of 3 meters per second (10 ft. per second) to 30% for velocities of 5 meters per second (16.5 ft. per second) and higher (V. A. Bodrov, 1940).

TREES ARE AN IMPORTANT CONSERVATION MEASURE

Shelter belts contribute greatly to uniform distribution of snow, to accumulation of moisture in the soil and to increase in yields of agricultural crops. Twelve years of observation at Kamenno-Stepnaia experimental station demonstrates that the yield of rye on the fields protected by shelter belts is 18% higher than on the open steppe. The favorable effect of the shelterbelts is particularly pronounced in years of drought and of dust storms.

Willows (Salix acutifolia Wild, s. daphnoides Wild, s. caspica L.) are widely used in stabilizing shifting sands everywhere, except in central Asia, where Aristida pennata Tu'n and other grasses are used. On stabilized sands and, also, on sandy loam and sandy soils, which are most subject to erosion, shelter belts of the type already described are established. Sandy areas are either planted to trees or are farmed and grazed—orchards and vineyards in the south and grazing in the deserts and semi-deserts.

Densely forested strips, 20-50 meters (65-165 feet) wide, are one of the means of stabilizing gullies (Figure 4). The purpose of these strips is to collect snow blown off the fields and to prevent runoff from melting snow from getting into the gullies. In addition to the usual hydraulic structures—flumes (Figure 5), drops, retaining walls, etc.,—living barriers of willow stakes and tree planting in the beds of the gullies have been extensively used in gully control in the U.S.S.R. as far back as the 18th century. Since the end of the 19th century (Yankovsky, Bortkevich), diversion terraces and diversion ditches have been employed to prevent storm water and melting snow from reaching the heads of gullies.

In addition to those described above, the following soil conserving practices are widely used in the U.S.S.R.: (1) Plowing on the contour to a depth of 20-27 cm. (8-11 inches) and deeper, which contributes to the absorption of melting snow; (2) plowing, cultivating, and planting across the slope; (3) strip cropping and reducing the width of cultivated fields on steep slopes.

The Quantitative Evaluation of Factors in Water Erosion—A First Approximation

G. W. MUSGRAVE

MR. MUSGRAVE is Research Specialist with the Soil Conservation Service, Washington, D. C. This article is the result of the findings of a group of workers showing the relationship between the major casual factors and the resulting rate of erosion. Included in the group are: T. C. Peele, H. O. Hill, O. E. Hays, John Lamb, Jr., George Browning, D. D. Smith, C. A. Van Doren, B. H. Hendrickson, and E. A. Norton.

IN THE DEVELOPMENT of any body of new information, early investigations first provide a basis for a *qualitative* evaluation of causal factors. Commonly, it is only at a much later stage of development that sufficient information is available to provide the *quantitative* expression of their relationship to the final result. For example, man learned to elevate his weapon directed toward a distant target and recognized the effect of wind upon his aim long before he learned to compute the trajectory of the missile and the proper allowances that should be made for various factors as they affected the direction of his weapon.

This situation has developed in connection with the studies dealing with the rate of erosion, particularly on agricultural lands.

Qualitatively the primary factors influencing the rate of erosion are known to be:

A. *Rainfall:* Characterized particularly by intensities and amounts in their determination of the energy of impact;
B. *Flow characteristics* of surface runoff particularly as affected by (1) slope degree and (2) slope length;
C. *Soil characteristics,* particularly those physical properties which affect erodibility; and
D. *Vegetal cover:* Characterized by comparative densities and protective effects.

Rainfall Characteristics

In the consideration of water erosion on agricultural lands, the primary casual factor, of course, is rainfall. It has been shown by Laws (13) and others that the size of raindrops varies considerably and that the velocity of impact likewise varies. The energy of impact produces a disintegrating force on the soil surface. In general, it has been found that raindrop sizes bear a certain relationship to the amount of rain falling within a given period of time. Many workers in several fields of hydrology have shown that the amount of runoff from a land surface is dependent to a considerable degree upon the amount of rain falling within a given period of time. Hays (8) has analyzed the data of more than a hundred different storms occurring at the La Crosse, Wisconsin, station, for each of which measurements of the amount of soil lost has been made. These data covered a number of different conditions representing seasonal changes of both soil and vegetal cover, and included numerous plots having different types of vegetal cover upon them. In these studies it was found that a very good relationship existed between the maximum amount of rain occurring within any 30-minute period and the amount of soil that was eroded during the entire storm.

Slope Characteristics

It is clear, also, that the erosive agent—water—varies in its effect upon the soil in accordance with the steepness of the slope and the length of the slope over which the water is permitted to flow. Other things being equal, greater velocities of flow occur on the steeper slopes and on those that have greater length.

A number of studies have been made of these factors and a preliminary analysis of them was made by Zingg (19). Since the time of Zingg's study (1940), a number of additional studies have been carried to the point where data from them are available, and a number of the earlier studies have also been carried over a longer period of time, now permitting a more comprehensive analysis of the relationships between slope factors and rate of erosion. Needless to state, there is the need for much additional information dealing with specific conditions. Nevertheless, there does exist today a sufficient body of data to permit a first approximation of the quantitative effects of these factors.

VEGETAL COVER EFFECTS

Intervening between the rain, with its erosive force, and the soil, there is normally a certain amount of vegetal cover that tends to intercept and disperse the energy of rain impact. The amount of protection provided depends largely upon the density of the vegetal cover and the presence of cover at those seasons when heavy rains normally occur. Crop residues on the soil surface and forest duff and leaf litter provide similar protection. The protective effects of woodlands and grass and range herbage are evaluated in accord with the intercepting potentialities of the cover.

SOIL CHARACTERISTICS

The erodibility of different soils varies with their physical properties. These properties comprise a complex of factors which thus far have escaped adequate numerical expression. However, soil technologists are able to classify soils into groups that have similar family characteristics and similar potentialities with respect to erosion. There is thus available a useful basis for evaluating erodibility of soils since many soils representing large groups or families have already been evaluated experimentally. The range of soils that has been studied is wide enough to include most agricultural lands and comparison of other soils with those that have been measured is feasible within reasonable limits of accuracy.

QUANTITATIVE EVALUATION OF MAJOR FACTORS

The quantitative evaluation of these major causal factors has been attempted with the clear recognition that in the present state of our knowledge only a first approximation of precise values is feasible. All of the numerous workers concerned with the evaluation appreciate the present limitations in basic information. However, the need of making the attempt to develop a usable working tool has, at the same time, been obvious.

The developments are largely empirical, resting upon the findings of nineteen research stations covering periods ranging from 5 to 15 or more years of measurement at the respective locations. Factors of minor importance have not been considered; both because basic information is inadequate and further because of the necessity of keeping the evaluation sufficiently simple as to be practical and usable.

Wherever possible the empirical findings have been compared with theoretical considerations. Where this has been done the values have appeared to be reasonable in magnitude.

DATA AND RESULTS

All data, both published[1] and unpublished, that bear upon the relation of these major factors to the rate of erosion were assembled. A group of research workers of the Soil Conservation Service was brought together to analyze these data and develop the most probable relationships that existed. The results can be very briefly expressed.

RAINFALL

Hays (8) had shown that erosion at the La Crosse, Wisconsin, station was correlated with the maximum amount of rainfall occurring within any 30-minute period. Other things being equal erosion was found to be approximately

[1]See Literature Cited.

proportional to $P_{30}^{1.75}$, where P_{30} represents the maximum amount of rainfall occurring in any 30-minute period. This relationship was then tested at several other stations including Guthrie, Oklahoma, Temple, Texas, Spartanburg, S. C., and Beemerville, N. J., and found to hold true within reasonable limits. Accordingly, as a first approximation the relationship of rainfall to erosion, E was found to be $E \propto P_{30}^{1.75}$.

THE DEGREE OF SLOPE

The results of a number of experiments on the effect of degree of slope on the rate of erosion have been published. In addition, several other experiments, the results of which have not been published, have now provided data covering three or more years of records. The most common relationship between degree of slope and amount of erosion per unit area was found to be

$$E \propto S^{1.35}$$

where E is erosion in tons per acre of dry soil and S is slope in feet per hundred.

Regardless of all other considerations, however, fairly extensive application of the empirical relationship $E \propto S.^{1.35}$ has given results that have appeared reasonable and that have coincided satisfactorily with all supplementary evidence that could be used as a basis of checking its validity.

THE LENGTH OF SLOPE

The existing data for slope length, L, to amount of erosion indicated the best relationship to be

$$E \propto L^{1.37}.$$

Equating the latter to a basis of unit area (tons per acre) it becomes

$$E \propto L^{0.37}$$

(which was subsequently off to $L^{.35}$).

VEGETAL COVER

A far more extensive body of research data is available on the effect of different vegetal covers upon erosion than is available with respect to slope factors. Analysis of these data placed the findings in three groups as shown in table 1.

TABLE 1

Relative erosion for different covers

Crop	Relative erosion
Continuous row crops (principally cotton, corn, tobacco uncontoured)	100
Small grains (wheat, oats, barley, rye)	15-40
Hay, pasture, woodland and forests less than	1

Subgroups are recognized under each of these main groups of crops and cropping practices, the magnitude of the effects varying somewhat from region to region. Continuous row crops contoured have a relative effect between 50 and 100% of that of the corresponding noncontoured continuous row crop. Small grain grown in regions that commonly experience heavy rains at seasons when the ground is either entirely without cover or only poorly protected by the vegetal cover has a relative effect toward the upper range of 15-40 (table 1). Hay, pasture, woodland or forest providing relatively poor cover (for this class) has the full relative value of 1. When the cover is excellent the value is .001 and intermediate degrees of protective qualities fall within these limits. Various special crops are recognized including peanuts, soybeans, potatoes and truck crops, cowpeas, etc., and rated relative to continuous row crops, which is the condition providing the largest amount of research evidence. In the same way various rotations and combinations of crops such as row crops with winter cover are rated according to the amount of protection they provide and relative to continuous row crops. An example of a further breakdown of the classification of vegetal covers is given in table 2. This applies to the Pacific Northwest in which a number of specialized cropping practices are common.

SOIL CHARACTERISTICS

Since the relative erodibility of a soil cannot be readily expressed by a single numeral in the

light of present knowledge, recourse is had to a table derived directly from the measured rates of erosion, using data from all places where experiments have been conducted for 5 or more years. Such a table in effect provides a scale of values for major soils whose characteristics are widely known and serves as a basis of comparison between soils of similar physical properties to one of those that has been measured.

TABLE 2

Relative amount of erosion under different vegetal covers values selected to apply to the Pacific Northwest

Crop or cropping practices	Relative erosion
Forest Duff	.001-1.0
Pastures, humid region or irrigated, excellent	.001-1.0
Range or seeded pasture	1-5
Range or seeded pasture (poor)	5-10
Orchards (a) Perennial cover, (b) Contoured, with winter cover crops	5
Legumes—Grass hayland	5
Crested wheat properly managed	5
Alfalfa	10
Small grain (standing or stubble)	10
Wheat fallow (stubble mulch)	10
Orchards—Vineyards (clean tilled, irrigated and contoured, not terraced)	15
Orchards—Vineyards (non-irrigated; with cover crops)	20
Wheat—Peas (stubble not burned)	20
Small grain (adverse rain at or after seeding)	40
Wheat fallow (stubble not burned)	60
Wheat fallow (stubble burned)	75
Orchards—Vineyards (non-irrigated, clean tilled, no cover crop)	90
Row crops and fallow	100

In table 3 these results from the experiments are given, including a column 7 in which the rates of loss per year for continuous row crops with their respective prevailing slopes and rainfall have been equated to equivalent rates on like slopes and with like rainfall. There is thus provided in column 7 a scale ranging from .03 to .96 inch depth of soil lost per year for these named soils under like conditions of cover, slope, and rainfall. Such a table permits comparison of soils which as yet have not been subjected to direct measurement of the rate of erosion, with a soil of similar physical properties whose rates of soil loss has been determined experimentally over a period of years.

TESTS OF THE EMPIRICAL FINDINGS

Numerous tests of the quantitative relationships that were developed as described above have been made. Even though rigid tests are not possible, numerous devices to test the reasonableness of the findings have been used, several of which are worthy of mention.

Soil technologists recognize the wind-blown soils at Pullman, Washington, and at La Crosse, Wisconsin, as being similar in many physical properties. They are primarily of the same particle size (silt), they are of considerable depth with profiles of much similarity and their erodibilities should be of much the same order of magnitude. Experiments conducted at both Pullman and La Crosse have shown that each with its differing rainfall and degree of slope has produced widely different rates of erosion (.14 versus .78 inch per year). When through the use of the quantitative relationships shown herein, the losses of soil are adjusted to equivalent slope and rainfall the similarity becomes apparent (.44 versus .45 inch per year).

Another approximate test is provided by table 3. Here it is seen that when the results from the 19 experiments for which extensive data have been reported are arranged in order of erodibility after adjustment to equivalent values for like slopes, rainfall and vegetal cover, (as in column 7), the soils arrange themselves generally with the silt loams at the top of the list in order of erodibility and the heavy-particled sandy soils at the bottom of the list. Included here also is the Bath flaggy silt loam which is a soil with flat stones on the surface. The silt loams are soils generally recognized as being highly erodible. The sandy soils with their heavy particles are moved with more difficulty. The order is logical and the results indicate that the evaluation of the factors used to compute column 7 is reasonably satisfactory.

In another test the loss of soil on a specific watershed at Colorado Springs, Colorado, was computed by relating this soil profile to that at Watkinsville, Georgia. The computed value was .0267 inch per year, whereas the value ob-

TABLE 3.—SOIL LOSSES ON DIFFERENT SOILS AT THE EROSION EXPERIMENT STATIONS WITH ADJUSTMENTS TO COMMON RAINFALL, DEGREE, AND LENGTH OF SLOPE

(1) Location	(2) Con. row crops	(3) Culture	(4) Slope *Percent*	(5) Slope length *Feet*	(6) Rate of erosion *In./Yr.*	(7) Col. 6 adjusted to 1.25-30 min. rain, 10% slope 72′ length *In./Yr.*[1]	(8) Soil
Geneva, N. Y.	fallow		5	72.6	.24	.96	Dunkirk SCL
Zanesville, Ohio	100		10	72	.64	.52	Muskingum SL
La Crosse, Wis.	100	C[2]	16	72.6	.78	.45	Fayette SL
Pullman, Wash.	fallow		30	72.6	.14	.44	Palouse SL
McCredie, Mo.	100		3	90	.10	.39	Putnam SL
Dixon Springs, Ill.		C	9	70	.20	.38E[3]	Memphis like SL
Bethany, Mo.	100		8	72.6	.32	.35	Shelby L
Marcellus, N. Y.	fallow		18.6	72.6	.47	.32	Honeoye SL
Clarinda, Iowa	100		9	72.6	.32	.33	Marshall SL
Blacksburg, Va.		C	5	58	.12	.31[4]	Dunmore SL
Blacksburg, Va.		C	10	58	.18	.31[4]	Dunmore SL
Temple, Texas	100		4	72.6	.18	.28	Austin C
Urbana, Ill.		C[5]	2	180	.04	.26[4]	Carrington SL
Dixon Springs, Ill.			5	70	.08	.21	Memphis like SL
Watkinsville, Ga.	100	C	7	70	.20	.20	Cecil SCL
Marlboro, N. J.	100	C	3	70	.034	.18	Collington FSL
Guthrie, Okla.	100		7.7	72.6	.10	.10	Stephensville FSL (Vernon)
Statesville, N. C.	100	C	10	72.6	.11	.09	Cecil SCL
Tyler, Texas	100		9	72.6	.11	.08	Kirvin FSL
Ithaca, N. Y.	100	C	18	72	.03	.03	Bath Flaggy SL

[1]Computed according to relationships of erosion to rainfall, slope degree and slope length as follows: Rainfall $P^{1.75}$; % Slope $S^{1.35}$; and Length Slope $L^{0.35}$.
[2]C—Contoured.
[3]Adjusted for non-contouring.
[4]Adjusted for length—corn in rotation.
[5]Contour ridged—corn in rotation.
E—Estimated from data of contoured plot.

tained over a seven-year period of measurement was .025 inch per year. Still other and more generalized tests of accuracy involve the calculation of the rates of erosion in various small agricultural areas of the United States and the results, thus secured through computation, when compared with the apparent relative rates of erosion that a careful observer of the areas sees, have appeared reasonable and satisfactory.

EXAMPLE COMPUTED

To illustrate the computation, an example from a midwest wheat producing area is given. The land slope is 5 percent, the slope length 150 feet, the maximum 30-minute rainfall 1.35 inches, and the soil is a silt loam generally similar in physical properties and erodibility to the Marshall silt loam.

In table 3, column 7, the basic rate for this soil is seen to be .33 inch per year, which indicates its relative erodibility with respect to other soils all under similar conditions of vegetal cover, slope and rainfall. The wheat crop in the specified area, however, has a rating of 20 percent of that of continuous row crops (see table 1). The rate for wheat therefore becomes .064 inch per year. On the 5 percent slope of the area instead of the 10 percent slope of table 3 the rate after adjustment[1] according to $S^{1.35}$ becomes .025. Adjusting for slope length of 150 feet the figure becomes .032 and adjusting for rainfall 1.35 inches it becomes .043 inch, the expected rate of soil loss.

If the area is alternately in wheat and fallow and it is desired to estimate the average loss

[1]The adjustments for the several factors can be conveniently made from graphs or tables. A very useful monograph also has been developed by A. W. McCulloch, Irrigation Engineer, Soil Conservation Service, that includes this calculation as well as several other calculations involved in the application of these reationships.

for a period of years, the vegetal cover factor then becomes $\frac{100 + 20}{2}$ or 60 instead of 20 as used above. In the same manner applications may be made to various other cropping practices, slopes, or rainfall.

NEED OF FURTHER INVESTIGATION

The need of further investigation of numerous phases of the problem is obvious. Among these in particular are the effects of slope and the underlying physical basis of soil disintegration and transport. This includes both the magnitude of the causal forces and of the forces of resistance, the characteristics of flow of water in thin sheets and the relation of them to sediment transport. Further, there is particular need to examine the possible interrelationships among these factors to determine whether any one of them exerts appreciable effects upon one or more of the others. It appears now that such intereffects if present are of relatively small magnitude but this is by no means certain. Additional studies of other characteristics of precipitation and their effects upon erosion are apt to disclose ways of developing better quantitative relationships. There is need also of investigating further the relation of varying range land vegetation to the rate of water erosion.

CONCLUSION

In brief, it is believed that the study has given rise to the development of a first approximation of the relationships between the major causal factors and the resulting rate of erosion. In its present development the method has given satisfactory results in many trial applications. In all probability, however, refinements in the procedure will be made as more evidence besomes available. The method is especially useful now in extending the findings from the localized areas shown in table 1 to a large number of similar soils in other parts of the country and for which there exists at the present time no other possible method of achieving a fully unbiased and entirely objective analysis of the existing erosion problem.

LITERATURE CITED

1. Borst, Harold L., A. G. McCall, and F. G. Bell. Investigations in erosion control and the reclamation of eroded land at the Northwest Appalachian Conservation Expt. Sta., Zanesville, Ohio. USDA Tech. Bul. No. 888. 95 pp. illus. May 1945.
2. Daniel, Harley A., Harry M. Elwell, and Maurice B. Cox. Investigations in erosion control and reclamation of eroded land at the Red Plains Conservation Experiment Station, Guthrie, Oklahoma. USDA Tech. Bul. No. 837. 94 pp. illus. January 1943.
3. Dickson, R. E., B. C. Langley, and C. E. Fisher. Water and soil conservation experiments at Spur, Texas. Texas Agr. Expt. Sta. Bul. No. 587. 67 pp. illus. July 1940.
4. Diseker, E. G. and R. E. Yoder. Sheet erosion and runoff studies on Cecil clay. Agr. Expt. Sta. of the Ala. Polytechnic Institute, Bul. 245. November 1936. 52 pp. illus.
5. Duley, F. L. and F. G. Ackerman. Run-off and erosion from plots of different lengths. Jour. Agr. Res. Vol. 48(6):505-510. March 15, 1934.
6. Einstein, Hans Albert. Bed-load transportation in mountain creek. SCS—TP—55. 54 pp. illus. August 1944.
7. Free, G. R., E. A. Carleton, John Lamb, Jr., and A. F. Gustafson. Experiments in the control of soil erosion in Central New York. Cornell University Agr. Expt. Sta. Bul. 831. 30 pp. illus. April 1946.
8. Hays, O. E. Studies of rainfall in relation to amount of erosion. (Unpublished report.) Soil Conservation Service, La Crosse, Wisconsin.
9. Hill, H. O., W. J. Peevy, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded land at the Blackland Conservation Experiment Station, Temple, Texas. USDA Tech. Bul. No. 859. 109 pp. illus. January 1944.
10. Horner, Glenn M., A. G. McCall, and F. G. Bell. Investigations in erosion control and the reclamation of eroded land at the Palouse Conservation Experiment Station, Pullman, Washington. USDA Tech. Bul. No. 860. 83 pp. illus. April 1944.
11. Knoblach, H. C., and G. D. Brill. Preliminary report of investigations at the Marlboro Soil Conservation Experiment Station. 21 pp. mimeographed. January 1940.
12. Krusekopf, H. H. The effect of slope on soil erosion. Mo. Agr. Expt. Sta. Res. Bul. 363. 24 pp. April 1943.
13. Laws, J. Otis, and Donald A. Parsons. The relation of raindrop-size to intensity. Trans., Amer. Geophys. Union, Part 2, pp. 452-460, 1943.
14. Lillard, James H., H. T. Rogers, and Jesse Elson. Effects of slope, character of soil, rainfall, and cropping treatments on erosion losses from Dunmore silt loam. Va. Agr. Expt. Sta. Tech. Bul. 72. 32 pp. illus. August 1941.
15. Musgrave, G. W., and R. A. Norton. Soil and water conservation investigations. USDA Tech. Bul. No. 558. February 1937. 182 pp. ??

(*Continued on page* 170)

Hydrology of Western Ranges

E. N. MUNNS

"Every spring the herds of sheep followed the melting snows into the high mountain meadows just as soon as the ground was uncovered. Not a thought was given to the tiny leaves of the forage plants just poking their tender points out of the soft, wet soil. The hungry sheep fed it off just as fast as it grew, and their sharp hoofs trampled and cut up the sod until bare wastes took the place of grassy meadows and bunchgrass hillsides. Here again it was first come first served. From the pinnacles the owners watched with jealous eyes each other's progress into the high ranges. By day the cloud of dust that rose above the migrating herds, and by night the fires built to keep off the predatory animals, showed the advance of the rival herds. Also, the fires were seldom extinguished when the herd moved on, and as the forest burned an added devastation followed the stockmen's course into the mountains.

The average band in the early days numbered from 2,500 to 3,000 head of dry sheep—far too many to be handled properly or graze on the range without injuring the forage plants. The owners saved the wages of one herder perhaps, but lost far more in other ways, not counting the damage such great masses of animals did to the range, a thing to which unfortunately they gave little heed.

This reckless competition could not have but one end. The mountains were turned into dust heaps; the old forage plants were gnawed to the roots and so weakened that they failed to grow. Worthless weeds and annuals took their place. The willows along the streams and meadows were eaten down to walking sticks. The meadows, stripped of their green covering, dried out. The forage cover gone, the freshets tore through the meadows leaving great gashes in the sod and soil, which cut down deeper and deeper, draining the land as successfully as any Corn Belt farmer ever drained his water-logged fields with machinery and tiling." (1)

WATER IS THE WEST'S most precious asset. It is more valuable than its gold or its oil: more valuable than its silver or its coal. The abundance or scarcity of water determines whether the countryside shall flourish and cities prosper or whether the land will remain parched and communities stagnate.

West of the Plains, Nature is niggardly with water. Along the west coast she has built great mountains as a barrier to the moisture-laden winds from the Pacific Ocean. As if in partial recompense, however, she has lifted the great land mass of the interior far above sea level, and has shoved upward still farther huge plateaus and massive peaks. Some of these soar a mile and more above the surrounding lands. Fortunately for man, these towering uplifts comb the sky for moisture. About their crests swirl the storm clouds; on their upturned faces settle the cold winter snows; upon their shelving slopes fall gentle rains or plunging cloudbursts. Here—high above the valley floor or arid steppe—the earth receives first the water of life.

THIS IS THE second in a series of two articles on Forest Hydrology by Edward N Munns, Principal Silviculturist in Charge, Forest Influences, Forest Service, USDA, Washington, D. C. *Hydrology of Western Ranges* is based on a series of watershed control plots and studies conducted by the Forest Service high up in the mountains of Central Utah.

WATER IN THE BEGINNING

Mountain and hill, valley and desert lay quiescent beneath the stars many centuries before the white man came. Over the ages great rock masses had been split, and their fragments shattered and broken by ice and heat. Soil formed over the face of the rock and vegetation modestly clothed it. And as each generation of vegetation had ripened and fallen, insects and other animals gently incorporated the plant remains in the soil mass. Thus the soil was built, enriched, and deepened. Land forms acquired stability under the vegetable cover, and drainage patterns became established. Topography, soil and vegetation were in equilibrium. Water from melting snows entered the soil softly, filtering its way to the stream or underground reservoir. Sharp summer rains beat harshly against the slopes, but the viciousness of their attack was broken by the resistant plant cover and its porous humus soil. This water too entered the soil quietly to nourish the plants and replenish the streams. Only occasionally was the water from rapidly melting snow or torrential rain unable to find room in the soil. And in those infrequent events, it flowed over a heavily carpeted surface, carrying with it to the stream some humic matter or the finer particles of displaced soil. Occasionally too, the stream which tumbled riotously downward to the valley lands took deep bites out of its unresisting stream banks or gouged out holes in its channel.

Then came Man. At first with bow and arrow, he followed the game. Time passed and other men came. They were content to pass quickly through the country. They were after gold — the glittering gold of the California sands. Some, more thoughtful, realized that here in mountain, plain and valley was another kind of wealth. Impressed, they settled on the land. They and others brought herds of cattle and sheep. At first, the flocks were content to wander slowly from meadow to meadow, only partially harvesting the luscious feed that grew waist deep on every hand. But as others saw and coveted the grass, larger and larger herds of cattle and great bands of sheep were driven from one watershed to another, each man vying with the other for the better range.

Fires burned unchecked for weeks. Some were accidents. Others were set to burn out one's rival; to green up the grass; to get rid of the brush; to open up the timber. Stampedes were created to scatter unwanted herds. Water holes were poisoned to keep invaders from choice areas. Meadows were fenced. But still the livestock came. The pressure seemed endless. Ridges became driveways; shady dells dust beds; waterholes wallows. The routes followed by the stock could be followed day in and day out by the clouds of dust stirred up by the thousands of hoofs that pounded the last remnants of vegetation into the soil.

Then came the droughts, the blizzards, and a depression. Stock perished by the thousands. Banks failed and stockmen lost their all. Stagnation came, then chaos. But from out of the chaos, order began to appear. Homesteads occupied the range, ranches were established, and fences divided the land. With the closing of major driveways, the great nomadic herds gave way to small resident bands. Most of the public mountain lands were put under administration. The open range—free to all—had shrunk.

Early administration of the range lands in the mountain and foothill areas was largely custodial. A permit system was developed, trespass forbidden, unauthorized stock removed, and fires curbed. Hesitant efforts at management practices were started: distribution of stock was attempted, seasonal use of the range invoked, and open rather than close herding prescribed. A start was made towards reducing livestock numbers to estimated range capacity. (2)

TOO MANY CATTLE AFTER WORLD WAR I

World War I demands for meat, leather and wool upset management plans. Pressures upon range lands generally increased and livestock above carrying capacity were permitted on the National Forests. But before excess stock could be moved, prices tumbled, leaving the range

Figure 1.—Contour trenches being completed. Cross-checks in the trenches prevent drainage of water, should outside bank fail. After trenches were constructed, all raw soil was reseeded to grasses.

badly overstocked. The range, both public and private, now was truly in awful shape. Sincere efforts to bring livestock numbers on public lands down to carrying capacity were painful. The anguish was felt in Main Streets throughout the West and in Congress. The decelerated rate of reductions only served to punish the range further and to make necessary still more reductions as the range further deteriorated under sustained heavy use.

Meanwhile, the demand for water was increasing. Irrigation was making valley lands prosperous and the desert productive. Power became an essential. Population was increasing. The crossroads became a community. Cities replaced the towns. Water meant permanence and wealth.

But even as requirements were increasing, water troubles began. Water tables declined, streams were shoaling, flow became more erratic. Some there were who blamed a major climatic change, others thought railroads or irrigation had affected the weather. Some believed geologic forces. Only a few tied water changes to land abuse. They were conservationists who knew plants and soils, who recognized that as the soil is bared and eroded, so are water behavior and quality affected. They also were those who understood how the land had suffered, how the plants had been mistreated, how the concentration of animals had set a vicious cycle in motion. They realized that if water troubles were to be avoided, attention must be directed to the headwater areas. (3)

The claims of those who related cause and effect were vociferously denied. To the younger generation and to newcomers who knew not the watersheds in their initial raiment, this was the way they ought to look. Vegetation was always sparse, for was not scanty rainfall to be expected? Are not severe storms commonplace? There never could have been any fish in these streams, for is not all this sediment but the normal bed load carried by the water? Are not these gullies and bare spots merely a reflection of thin soils, a rocky ground, the scorching sun, an arid land? Are not flash floods but an act of God? In such an atmosphere, research was undertaken, research to determine how the bare spots came to be, why the cover was so thin, why native forage plants had disappeared, why the sudden floods and the mud-rock flows.

WATERSHED CONTROL PLOTS ARE ESTABLISHED

High up in the mountains of central Utah, a mile above the valley floor, some plots were established. These quickly confirmed observational evidence that bare ground produced immediate run-off and much sediment. Gages were installed in two small watersheds, 10 acres each. One of the areas (B) was in reasonably good condition, about 40 percent of its soil surface being covered with perennial vegetation, mostly grasses and weeds. The other drainage (A) had only a light stand of vegetation, mainly annuals which covered about 16 percent of the surface. Both units were maintained in their respective present condition during the first 6 years by grazing, B by careful grazing use, and A by use common to the rest of the country. Then conditions were changed. The cover on A was encouraged. Perennial grasses and weeds

were introduced and the cover was protected from grazing until after several years it had a cover resembling that on B.

The change in regimen was striking. The increase in vegetation on A caused a reduction of 64 percent in surface run-off from summer storms and a reduction of 54 percent in the amount of soil material removed. The range conservationists were now certain that land abuse was the primary cause of floods and erosion. (4)

The disbelievers still were not convinced. To answer them, watershed A is being allowed to improve steadily, while watershed B currently is being disgracefully abused. The cover on B has already been battered and worn below that originally on A. Again the results tell the story for B is now yielding surface run-off from each trivial shower and producing heavier loads of sediment. Difficulty in keeping the instruments in running order is increasing. An average summer storm now certainly demonstrates the obvious to all but those who will not see.

CLOUDBURSTS HIT WASATCH MOUNTAINS

Even as the early results from A and B areas were becoming evident, Nature entered the argument. Summer storms—some experts call them "cloudbursts"—hit the Wasatch Mountains. Out of the canyons onto the valley came great flood waves of mud and rocks, spewing great boulders like so many pebbles over rich farm land and valuable orchards. Prosperous communities were deluged. Buildings were crushed, bridges and highways destroyed. Silt-formed deltas that had lain quietly under the sky for thousands of years while the vast ancient Lake Bonneville was shrinking into present day Great Salt Lake, were covered with boulders and rock debris.

The new type of floods hit here and there. One season it was in the north, then in the south. Idaho and Wyoming as well as Utah experienced them. People began to fear their might. In the Davis County (Utah) area, conditions were particularly bad for floods struck several times and property values depreciated rapidly. (5) A new demon was on the loose. Could nothing be done?

Conservationists thought watersheds A and B provided the answer. Following up the Davis County creeks to the higher elevations, they discovered that the great onrushes of water originated on relatively small areas in the headwater regions—an acre here, several acres there, and other patches of larger size. On them some fire but much more often, heavy grazing and repeated trampling had virtually destroyed the grass and weeds, had killed out the smaller shrubs, and had hedged up and weakened the larger bushes, willows and aspens. Not only was the soil bare of cover, but everywhere it bore rills and gullies, the unmistakable clawmarks of excessive surface run-off. Where the open patches were entirely surrounded by dense vegetation with its litter cover, the water had soaked away leaving its soil load on the surface. Where the openings were close to the drainage ways, the wave of water had gouged deeply into the bed of the channel.

Digging into the soil on the slopes, the investigators found more of the story. The surface soil was deep enough and porous enough to hold 2 or 3 inches of water. In the vegetated areas, the water had penetrated downward almost a foot. In the bare areas, the water had only moistened the first 2 or 3 inches of soil. The depth of mositure in the covered areas showed that less than 2 inches of rain had fallen. All the water had been absorbed because the surface showed no sign of disturbance. On the barren areas only about a third of an inch of water had entered the soil. The rest had run off. It was clear—floods began on bare spots where surface water could congregate: where the land was protected there could be no such run-off because the permeable soils absorbed the water. When only the outflow from casual rains reached the channel, the stream would carry only soil building and soil enriching material. Where sudden surges of water burst into the channel, the riotous waters would tear out the side walls and rip the chan-

Figure 2.—Reseeded contour terraces. In a year or two, vegetation has reclothed the trenches and reestablished infiltration.

nel bottom. Thus the debris-flows were formed.

Once the local people understood the lessons of A and B and what their own area indicated, they acted. They insisted on public ownership and control of the grazing lands, leading the way with the initial purchase. They brought about the elimination of grazing on watershed lands. They insisted on more vegetation. Under the leadership of Reed W. Bailey, Director of the Intermountain Forest Experiment Station, the research men pioneered. They constructed trenches along the contour designed to hold about 2 inches of water before spilling. They seeded the trenches and all exposed soil to grasses and encouraged the native vegetation. (6)

The value of these simple works was quickly demonstrated. Just as the trenches on one small drainage had been completed, a storm hit the area, a storm that in its effects resembled the cloudbursts that had been so destructive. On 75 acres of the untreated portion of the watershed, a mud- and rock-flow originated. Damage was great as the mud-flow debouched upon the valley a mile below carrying boulders 9 feet across. But the measured "cloudburst" turned out to be only a summer shower that dropped less than half an inch of water. From the treated portion of the area however, virtually no water reached the stream channel, most of it was caught and held back by the terraces.

CONTROL WORK IS EFFECTIVE

On July 10, 1936 another "cloudburst" hit the Davis County area, bringing 1.14 inches of rain. In the forepart of the storm, the rain fell at a rate of 5.04 inches per hour for a five-minute interval. The run-off out of 4 subbasins of Farmington Creek caused 4 distinct mudflows, but no control work had been done in any of these. Practically no run-off at all occurred from the treated areas. The experiment station men found that the overland storm flow from 15 acres of roadways and campgrounds amounted to 50 percent of the precipitation.

On August 19, 1945 another cloudburst storm hit Utah. High in the mountains the gages recorded a fall of 1.06 inches in an hour, with a record-breaking intensity of 6.84 inches per hour for 5 minutes. Fortunately for Davis County, the work of trenching and reseeding had been completed. Peak flows out of the mouths of the several canyons scarcely showed

on the recorders for the discharge was only about 5 cubic feet per second. On overgrazed and burned lands just outside Salt Lake City however, the same cloudburst caused a flood and mud flow with a discharge of about 3,000 cubic feet per second per square mile that did $350,000 damage in just a few minutes.

Today as one stands on the divide and looks down upon the valley of the Great Salt Lake, one marvels how such simple measures can do so much. The barren and eroding areas of only a decade ago today are carpeted with vegetation. In some places it is almost impossible to distinguish between the former "sore spots" and those which had not previously lost their cover. In some places, one can only faintly trace the outlines of a trench. Each year as plants extend their influence, as the litter grows thicker, as the soil becomes more porous, the menace from cloudburst floods recedes. Each year as the plants enrich the soil and the roots bind its particles ever more tightly together, nature increases the infiltration and water-holding capacity of the soil. Each year as cloudbursts hit the mountains, the local residents wonder, "Is it really raining upstairs?"

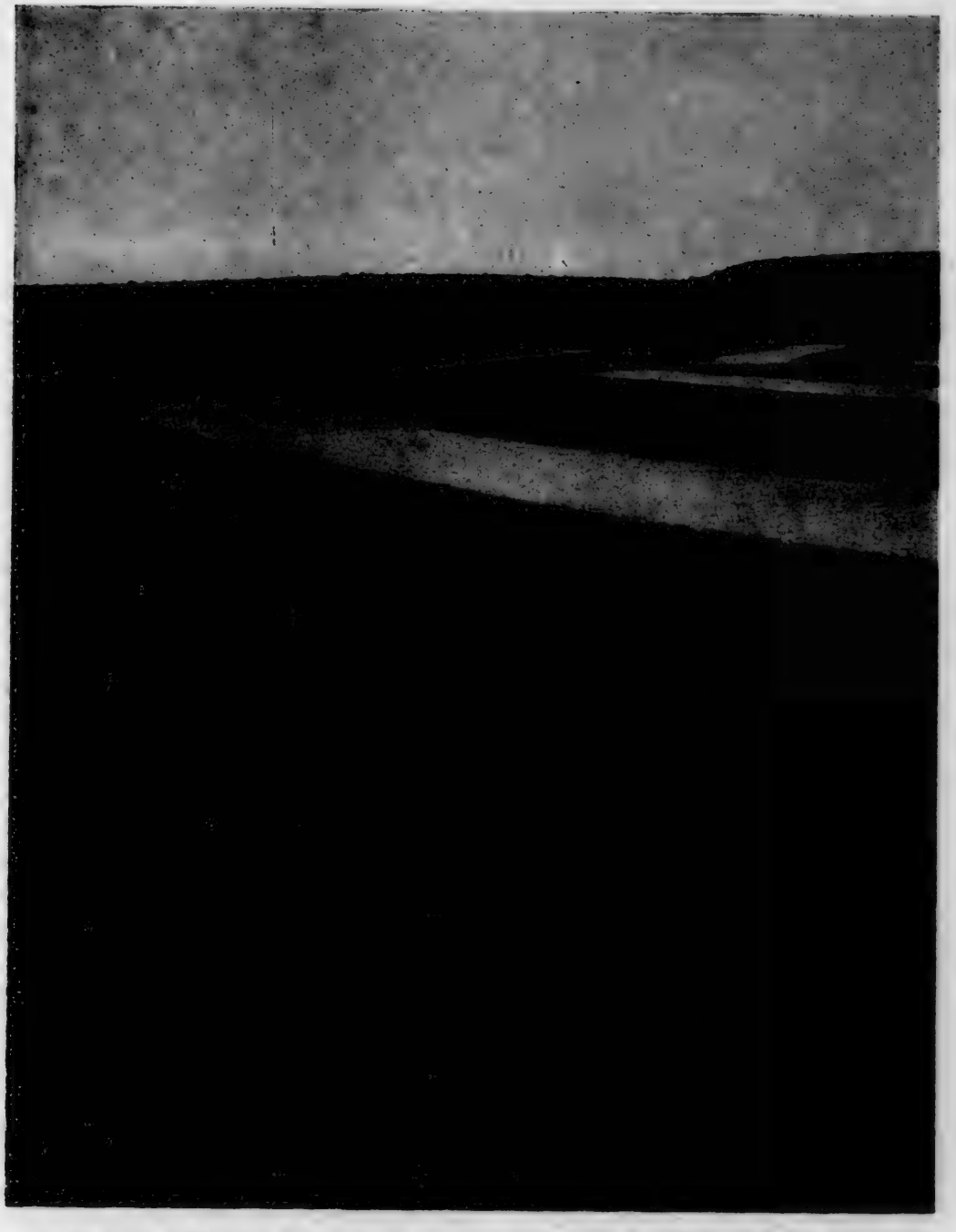
WATERSHED MANAGEMENT PAYS DIVIDENDS

Davis County today is a monument to the imagination, skill and daring brought to a difficult task by research men. The story is a stirring epic of resourcefulness. It demonstrates that flash floods can be tamed, that destructive erosion can be halted. It demonstrates that watershed management can pay dividends, dividends of safety and clear water supply. (7) The pity of it is that even as this work stands for all to see and evaluate, one agency of little faith even now is warning the local people of further disasters, that there is no hope of control, that suffering and drouth will be their lot.

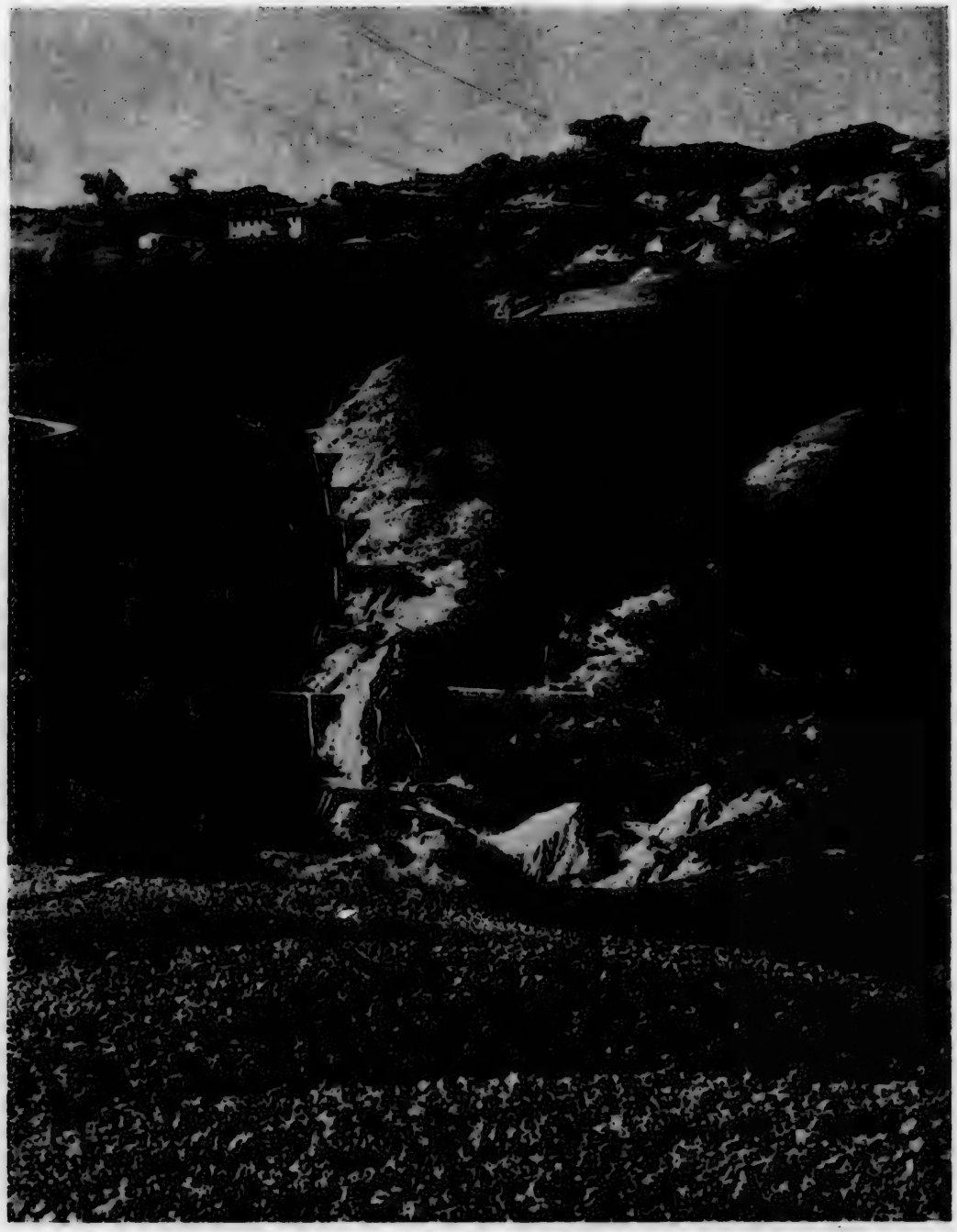
Today research men in the West face other kindred problems, more tough, more discouraging, more troublesome than those of the central Utah ranges. (8) Possibly the most heartbreaking and challenging of them all is the sediment problem. Water is precious. Reservoir sites scarce and dams costly. Every acre foot of reservoir space reserved for water that is occupied by sediment threatens the prosperity of the future. We of today must recognize our responsibility to the future, hence sedimentation must be brought under control. The attack on the problem throughout the West must go on vigorously. To this end the research men of today and tomorrow must bring their imagination and daring even as they have to the mud-rock flows.

LITERATURE REFERENCES

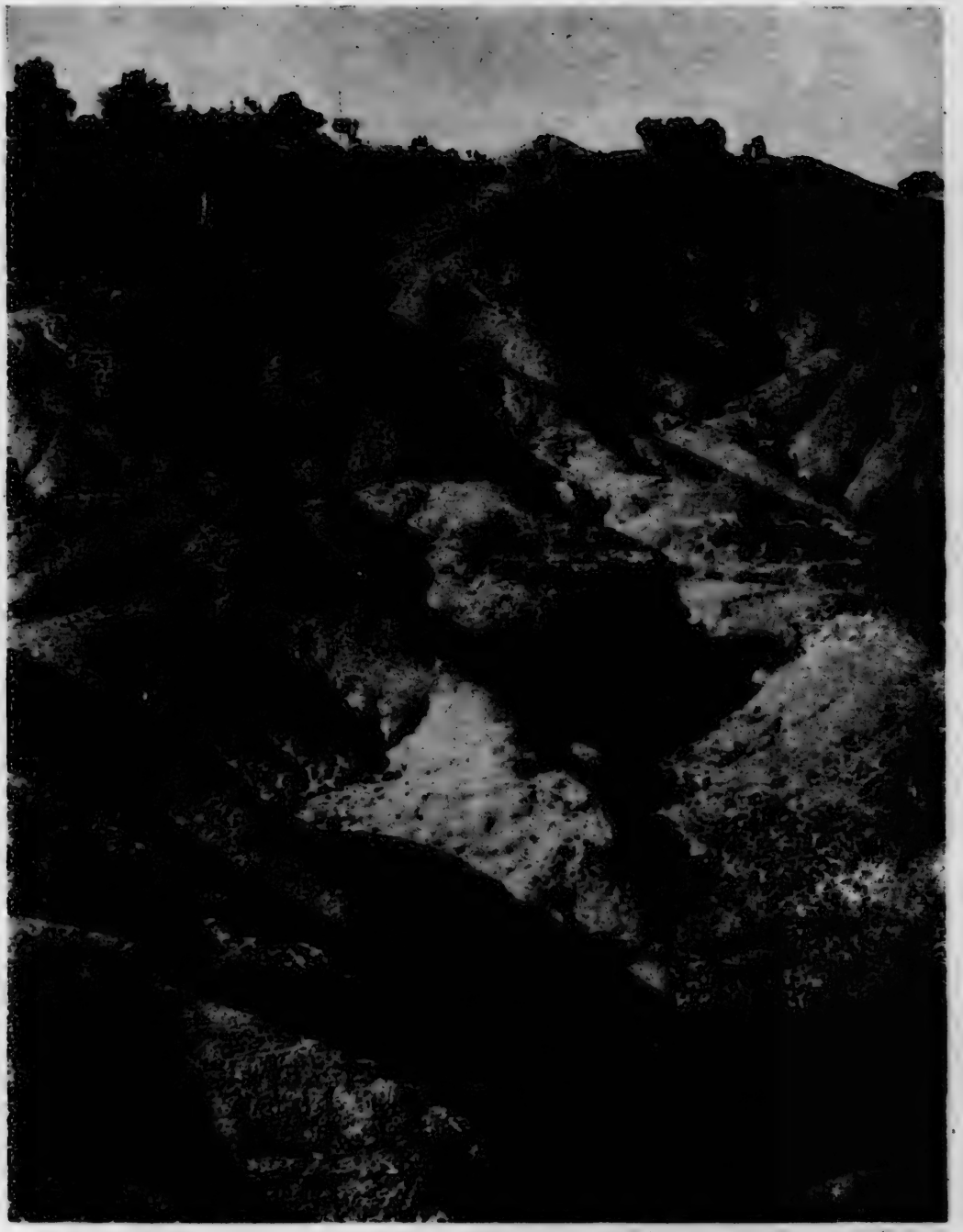
1. Barnes, Will C. Story of the Range. 60 pp. 1914.
2. The Western Range. Letter from Sec. of Agric. Senate Doc. 199, 74th Cong. pp. 620. 1936.
3. Munns, E. N., W. R. Chapline, R. D. Forks, L. F. Kellogg, H. G. Meginnis. Watershed and Related Forest Influences. A National Plan for American Forestry. Senate Doc. 12, 72d Cong. pp. 296-461. 1933.
4. Forsling, C. L. A Study of the Influence of Herbaceous Plant Cover on Surface Runoff and Erosion in Relation to Grazing on the Wasatch Plateau in Utah. USDA Tech. Bul. 220. 72 pp. 1931.
5. Report of Special Flood Commission. Torrential Floods in Northern Utah. 1930. Utah Agric. Exp. Sta. Circ. 92. 1931.
6. Bailey, Reed and A. R. Croft. Contour Trenches Control Floods and Erosion on Range Lands. Emergency Cons. Work Forestry Pub. 4. 22 pp. 1937.
7. Bailey, Reed. Mountain Floods and Vegetation. Proc. Sixth Pacific Sci. Cong. IV. pp. 731-736. 1939.
8. Bailey, Reed. Epicycles of Erosion. Jour. of Geology 43, 337-355. 1935.



Contour cultivation and strip cropping near Gatesville, Texas. Good husbandry protects the soil and forms the basis of a stable agricultural economy. Photo by J. T. Mitchell of the Soil Conservation Service.



The reclaimed area in the Val d' Orca, Italy, shows how silt dams with concrete-lined spillways in the main gully take care of gradient ditch or terrace runoff. The crops are: sulla and barley, later, wheat 2-3 years, alfalfa 3 years, or clover 1-2 years. Photo by Dr. Claude Fly.



Advancing erosion threatens farm homes and even small villages in the Consorzio Bonifica Val d' Era of Tuscania, Italy. The brush silt dams behind which tamarisk and other trees will be planted are in the Era Valley Land Improvement District. Photo by Dr. Claude Fly.

Saving what is left of the soil when the forests are gone. Artificial terracing in Shan-si Province, China. This photograph was taken in 1903 by Mr. B. Willis. Photo by the Forest Service.

Soil Moisture Relationships on Range Land

LESTER F. LAWHON

MR. LAWHON, a Survey Supervisor for the Soil Conservation Service with headquarters at San Angelo, Texas, discusses herein the monthly distribution of rainfall, soil texture, slope and moisture relationships on range land in the southwest.

TO UNDERSTAND moisture relationships on range land we need to study the source of moisture, how it is stored and how it is used in plant growth.

First consideration needs to be given to rainfall, the primary source of moisture. We need to study its characteristics to learn how much of it is available annually, in what seasons of the year it occurs, and its form, intensity and duration.

The range land in western Texas and Oklahoma has annual rainfall that varies from seven inches in the extreme west to 30 or more inches in the eastern part, with fluctuations of from less than an inch to over 50 inches some years. With such a variation in rainfall, it is well to note that areas in this western Texas and Oklasoma region receiving 6 or 10 to 16 or 20 inches annually are semiarid; 16 or 20 to 26 or 30 inches are subhumid; and 26 or 30 to about 40 inches are transitional, or approaching humid conditions. The variations in limits depend on the permeability and available moisture capacity of the soil.

Next to be considered is the time of year in which rainfall occurs. Is it regular throughout the year, or does it rain more some months or seasons than others? A study of rainfall records reveals that in the semiarid areas a large part of the annual rainfall comes in the late summer and early fall, with little or no rainfall at other times (Figure 1). The subhumid areas have rainfall in the late summer-early fall period plus rainfall in the spring (Figure 2). In the transitional area the peak rainfall is in the early spring (Figure 3) with some rains falling at rather short intervals throughout the year. July and August are the most frequent drought periods; rainfall at this time is greater than during the winter, but there is more evaporation in proportion.

The other important characteristics are the form, intensity and duration of the precipitation. Forms are rain, snow, sleet, hail and dew. Rain is the greatest in volume; snow contributes to winter moisture in the northern parts of western Texas and Oklahoma. The other forms are minor in importance.

The intensity, or rate, and the length of time that rain falls have much to do with the location at which moisture is stored. Throughout the area under consideration the rains of high intensity are about equal both in rate and duration. However, the percent of total rainfall occurring as high-intensity rains varies from about 90 percent in the semiarid area to less than 40 percent in the transitional area. The balance of

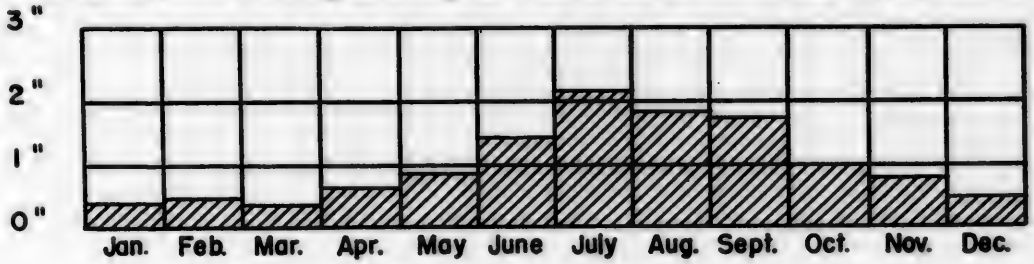


Figure 1.—Monthly distribution of rainfall for semi-arid areas.

the rainfall is of low intensity.

The second source of moisture is runoff water from higher lying land. Runoff occurs when more water falls than can be taken into the soil. The amount and behavior of runoff are affected by (1) the amount of water present, (2) the slope of the land, (3) the rate of water intake, or infiltration, into the soil and (4) obstructions to flow. The amount of water present is usually the direct result of rainfall plus runoff from higher land.

The slope of the land and its relation to surrounding areas determine whether it is an area which contributes water to other locations or whether it receives water. This relationship can generally be described by one of five topographic positions (Figure 4). Bottomlands and lowlands may receive more moisture from runoff than from direct rainfall.

Exposed stone surfaces may have the effect of increasing the moisture available to the soil nearby. In miniature a stone behaves like a slope and sheds runoff; the adjoining soil receives extra water.

The third source of moisture is underground water which returns to the surface. Underground water may appear in small seep spots or in areas of several thousand acres such as are affected by large springs and flowing wells. However, this source of moisture is of minor importance except in certain areas.

Of the five topographic positions shown in figure 4, footslopes and hillsides usually contribute to runoff. This means that when rainfall is of sufficient intensity and duration these sites cannot absorb it; they do not get the full benefit of the available moisture. The excess moisture, so far as these sites are concerned, is lost.

Another means of moisture loss is through deep percolation. Excess water in the soil moves downward until it encounters an obstruction to its downward movement. If enough water collects in this manner it may move as an underground stream or remain as a water table.

When the soil is warmed by the sun, moisture stored near the surface vaporizes and goes into the atmosphere. The higher the tempera-

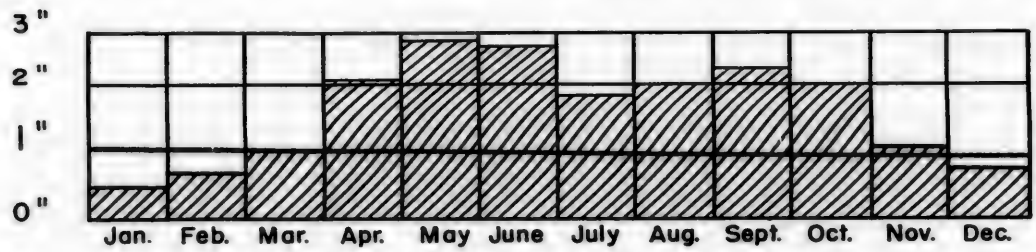


Figure 2.—Monthly distribution of rainfall for sub-humid areas.

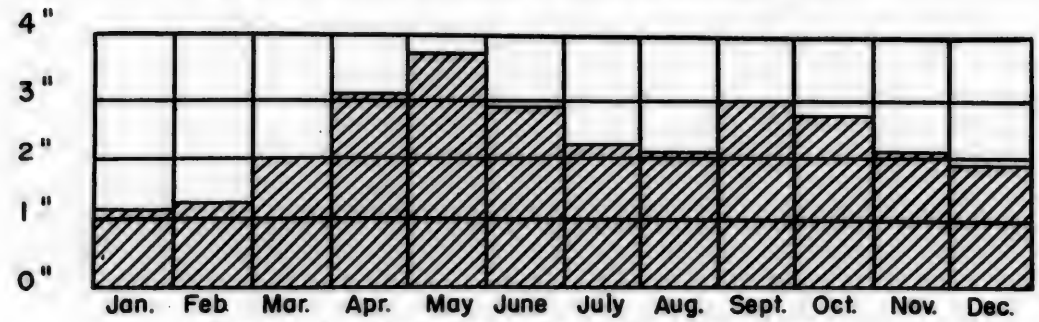


Figure 3.—Monthly distribution of rainfall for transitional areas.

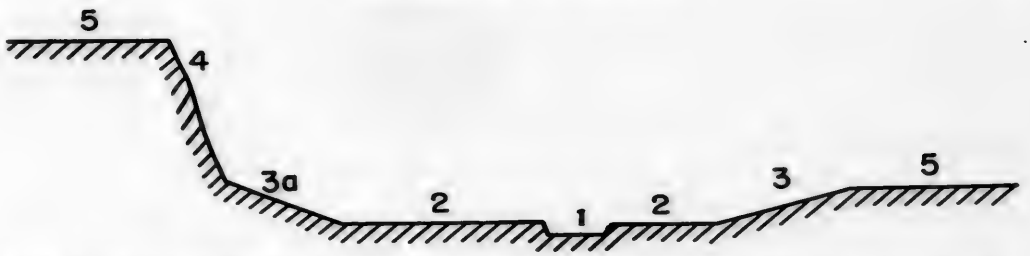


Figure 4.—Slopes and moisture relationships. (1) Bottomland—receives large and frequent amounts of run-off in the form of stream overflow. (2) Lowland—nearly level areas which receive run-off from adjacent, steeper or higher lying areas. (3) Footslopes—gently sloping or rolling areas which usually contribute to run-off. (4) Hillsides—steep areas which always contribute to run-off. (5) Plateau or Plain—nearly level areas which neither contribute nor receive very much run-off. (Note: An apparent footslope—3a—may actually have about this same moisture supply in that it may be a receiving as well as contributing area.)

ture the more rapid this process. As moisture leaves the surface it is partly replaced from moisture stored deeper in the soil. If the air above the soil becomes saturated, the moisture may condense and fall, but if the air moves away from the place where it received its moisture and is replaced by dry air, the evaporation process continues. Thus, dry winds, such as occur at times in most of the western Texas and Oklahoma area, not only speed up evaporation but carry the moisture completely away. Highest rates of evaporation thus occur when temperatures are highest and when dry winds are prevalent. The highest temperatures normally come in July, August and early September; the high velocity winds in February, March and sometimes April. This reduces the affectiveness of moisture available at these times (see Figures 1, 2 and 3).

Transpiration by growing plants also removes moisture from the soil. If the vegetation is a desirable type we consider this as water use rather than loss.

Since most plants cannot take in all the moisture they need in the short time that the free water is available, the moisture needs to be stored within reach of the plants. This storage is handled almost entirely by the soil. Only a few plants can store reserves of moisture.

Soil depth has much to do with the amount of stored moisture which plants can use (Figure 5). The deeper the soil the greater its storage and the longer its moisture is available to plants.

The upper layer of soil, to a depth of about three inches, is subject to wide fluctuations in temperature. The fluctuations are much wider if the soil is bare than if it is covered with vegetation. As a result, a crust or "desert pavement" is formed, which consists of successive layers less than one-fourth of an inch thick, with a total thickness up to three inches. The crust seals the soil effectively and practically prevents infiltration of water. Soil temperatures up to 140 degrees F. have been observed in this desert crust.

Evaporation dries the surface layer to a depth of eight or ten inches more rapidly than mois-

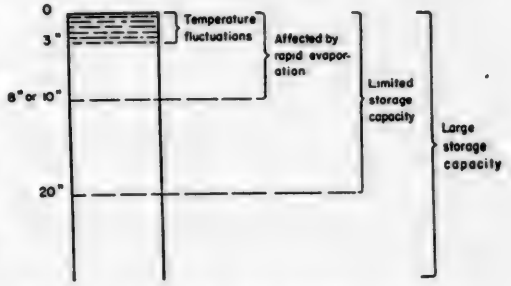


Figure 5.—Soil depth and moisture relationships.

ture moves into it from the deeper soil. If evaporation continues, this surface layer becomes air dry or nearly so.

Another important soil characteristic is the size of the soil particles—the soil texture. Soil moisture forms a film that adheres to the soil particles. The finer the soil particles, the greater amount of surface is present to hold the film (Figure 6). Consequently, the finer the soil particles, the more moisture is required to "wet" the soil. A fine-textured soil usually requires two to three inches of water to wet it to a depth of 1 foot, a medium-textured soil from one to two inches, and a coarse-textured soil less than one inch. (These values to not include hygroscopic moisture which is usually considered as present in soils under field conditions).

The third characteristic of the soil, when considered as a storage reservoir for moisture, is soil structure—the manner in which soil particles or groups of soil particles are fitted together. If the particles are arranged so they fit closely, as a bricklayer stacks bricks, very little space is available for moisture storage and freedom of moisture movement is restricted. On the other hand, if the particles are loosely arranged, as a pile of bricks or round stones, much more space is present for storage and greater freedom of moisture movement is permitted. Thus, available moisture capacity and permeability (the ability of the soil to transmit or permit the movement of water or air) are influenced by soil structure.

Surface soil permeability, or infiltration rate, is greatly influenced by surface cover as well as size of soil particles and structure.

As examples of how the foregoing information may be interpreted:

Fine-textured, slowly permeable soils on the plateau or plains position, as shown in Figure 4, have a depth in inches approximately equal to the average annual rainfall. Deeper soils are formed in the depressions where water accumulates, and shallower soils on the gentle slopes where runoff occurs. Therefore, unless some obstruction such as extremely resistant lime-

Figure 6.—Soil texture and moisture relationships.

stone is present, the depth of the soil is a good index to topographic position and amount of moisture available for use by plants. This is especially true in the semiarid and subhumid areas.

A fine-textured, very slowly permeable soil may have an infiltration rate of .01 inch per hour if the surface is bare and crusted, or .5 inch per hour under excellent grass cover. Two to three inches of available moisture may be stored for each foot of soil depth. Although the total amount of soil particle surface is relatively large the very small soil particles fit closely together, making the size of the pore spaces very small. Soil moisture moves very slowly through the tiny openings.

The other extreme is a coarse-textured, very rapidly permeable soil. The infiltration rate may be in excess of three inches per hour, but the soil's ability to store available moisture may be less than .5 inch per foot of depth. The amount of soil particle surface is small but the openings between particles are large. The coarse soil particles fit together loosely and soil moisture moves rapidly through the large openings.

For any given site, there is a combination of plants which best can utilize the available moisture. This combination is known as the climax vegetation. Climax plants must not only have root systems adapted to the site, but also must furnish sufficient top growth to prevent raindrop impact, retard runoff and adequately shade the surface to reduce evaporation to a minimum. To see the effect of vegetation on the storage of available moisture, observe comparable soil sites—one with a good grass cover, the other bare—and note the difference in depth of moisture penetration two or three days after a rain. When the top growth repeatedly is re-

(*Continued on page* 170)

Technical Standards and a Technical Guide in Soil Conservation Work

ARNOLD J. BAUR

THIS ARTICLE by Arnold J. Baur outlines the basic principles of a technical guide used for the planning and application of conservation farming. Mr. Baur is State Soil Scientist for the Soil Conservation Service with headquarters at the Agricultural Experiment Station, Cornell University, Ithaca, New York.

FROM ITS VERY BEGINNING, the Soil Conservation Service has stressed a high technical standard as one of its strong points.

Maintenance of high technical standards in the field is not easy in a program as complex as soil conservation. Since each farm has its own set of physical conditions such as soil, slope, erosion, and size and shape of fields, the uses of the land and the supporting practices which may be applied must be based on careful study and the best available techniques. Then, too, a farmer's conservation program is influenced by his personal attitudes and preferences.

Many Factors Affect Standards

Type of farming, shifts in price and farm income and labor supply—all have a bearing on the soil conservation work. In soil conservation operations, as in all good business, there is always pressure for higher production. This means planning and applying more units of conservation per day. With all of these factors involved, it would be easy for soil conservationists to let their standards slip.

To assure conservation procedures of uniformly high quality, Soil Conservation Service technicians in the Northeast Region have, for the past three years, been using a device known as a Technical Guide. This Guide is related directly to technical standards. Made up usually to cover the area in a soil conservation district, it gives a complete outline for the planning and application of conservation farming. It contains the soil and water conservation program for the area to which it applies. Even more than that, it is an outline which relates the conservation program to the soil, slope and erosion conditions on the land. This is done by making use of the system of land-capability classes, whereby each section of a farm is designated for the use to which it is best adapted.[1]

The land-capability classes are an interpretation of the conservation survey. In the survey a map is made of each individual farm showing soil, slope and erosion conditions. The capability classes are based on the maximum intensity of safe land use, and the supporting conservation practices needed to keep the land in that use without damage.

The Technical Guide has a foreword which defines its objectives and shows how it is related to the Program and Work plan of the district. This is followed by sections containing the conservation survey legend, descriptions of the land-capability classes, and a diagram or table showing basic soil relationships according to geological origin and drainage conditions.

Soil Groups Listed

Soils with common characteristics are listed in soil groups. These soil groups are numbered and a page of recommended conservation practices is prepared for each of them. This is the most important section of the Guide. Here, in ready-reference form, a farm planner can find the proper conservation practice needed for any cropping system likely to be desired by the farmer. In the back of the Technical Guide, "job sheets" are placed which contain detailed

[1]See R. D. Hockensmith's article, "Scientific Basis for Conservation Farming," Volume 2, No. 1 of the *Journal* for a comprehensive discussion of the concept of the land-capability classification.

SOIL GROUP—1

SOILS

81 & 82 Honeoye silt loam
78 Honeoye gravelly silt loam
83 Honeoye silt loam (deep phase)
77 Pittsfield gravelly silt loam
84 Lansing gravelly silt loam
• 87 Lima silt loam (imperfectly drained)
• 187 Lima gravelly silt loam (imperfectly drained)

DESCRIPTION

Includes non-stony, upland soils developed on deep calcareous to mildly calcareous glacial till containing varying amounts of limestone, sandstone, shale, and some granites. Common characteristics are friable surface soil and moderately friable subsurface soil that becomes compact with depth, merging into a compact till. Surface drainage is good; internal drainage fair. This compactness makes them quite susceptible to both sheet and gully erosion.

These soils are adapted to most any crop grown in the area. They are the most highly productive upland soils in the county.

LAND CAPABILITY CLASS

Slope	Erosion				
	0, +, 1	17, 2, 27	2(7), 27, 3 37, 3(7)	38, 4, 47 4(7), 48	3(8), 4(8), 5 6, 9
A	I				
B	II	II	III		
C	III	III	III	IV	
D	IV	IV	IV	VI	VII
E	VI	VI	VI	VII	VII
F	VII	VII	VII	VII	VII
BR	III	III			
CR	III	IV	IV	VI	
DR	IV	IV	VI	VI	VII

CONSERVATION PRACTICES AND TREATMENT ACCORDING TO CAPABILITY CLASS AND LAND USE

LAND CAP. CLASS	LAND USE	SEED, TREE, AND SHRUB, MIXTURES	TREATMENT			SUPPORTING PRACTICES
			Fertilizer	Manure	Lime to pH	
I	Row, row, row, row, small grain, hay 2-4 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay and pasture) ladino clover 2#, timothy 7# (if heavily pastured).	300# of 20% phosphate with manure every year on row crop.	12	7	Contour cultivation Cover crop
	Row, row, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome grass 8# (both hay and pasture)—ladino 2#, timothy 7# (if pastured heavily).	400-500# of 20% phosphate with manure for each row crop. 300# of 20% phosphate with small grain (no manure).	12	7	
II	Row, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino clover 2#, timothy 7# (if heavily pastured).	400# of 20% phosphate with manure for row crop. 300# 20% phosphate with small grain (no manure). Top dress new seeding with 300# 20% phosphate with manure. Top dress every three years using 450# phosphate with manure.	12 10	6.6	Contour cultivation Contour strips—125-150' wide Diversions Outlets
	Row, small grain, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino 2#, timothy 7# (if heavily pastured).	600# 20% phosphate with manure for row crop. 300# 20% phosphate with second small grain (no manure). Top dress new seeding with 300# 20% phosphate with manure.	12 10	7	
	Row, row, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino 2#, timothy 7# (if heavily pastured).	500# 20% phosphate with manure for each row crop. 300# of 20% phosphate with small grain (no manure).	12		
III	Small grain, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino clover 2#, timothy 7# (if heavily pastured).	350# of 20% phosphate with each small grain crop (no manure). Top dress new seeding with 350# 20% phosphate with manure. Top dress every three years using 450# 20% phosphate with manure.	 8	7	Contour strips—125-150' wide Diversions Outlets Sod waterways
	Row, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 8#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino clover 2#, timothy 7#, (if heavily pastured).	400# 20% phosphate with manure for row crop. 300# 20% phosphate with small grain (no manure). Top dress new seeding with 300# 20% phosphate with manure. Top dress every three years using 450# phosphate with manure.	12		Contour strips—75-125' wide Diversions Outlets Sod waterways
	Row, row, small grain, hay 2-5 years.	Alfalfa 6#, M.R. clover 4#, alsike 2#, timothy 6#, Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino clover 2#, timothy 7#, (if heavily pastured).	400# 20% phosphate with manure with each row crop. 300# of 20% phosphate with small grain (no manure). Top dress new seeding with 300# 20% phosphate with manure.	12 10		
IV	Long term hay.	Alfalfa 8#, timothy 6#—Alfalfa 8#, smooth brome 8# (both hay & pasture)—ladino clover 2#, timothy 7# (if heavily pastured).	600# 20% phosphate with small grain. Top dress new seeding using 300# phosphate with manure. Top dress every three years using 450# 20% phosphate with manure.	 10 10	7	Contour strips—100-125' wide. Diversions Sod waterways Outlets Field Strips
	Supplemental Pastures.	Sudan grass 24-32#.	300# of 20% phosphate with manure.	12	7	
	Hedges.	Hybrid filbert, cultivated blueberry, highbush cranberry, tatarian honeysuckle, multiflora rose.	300# of 20% phosphate with manure.	10	7	Wildlife area management—pruning.
	Windbreaks.	Highbush cranberry, tatarian honeysuckle, 2 rows spruce, highbush cranberry, tatarian honeysuckle, hybrid filbert, 2 rows spruce.	300# of 20% phosphate with manure.	10	7	Cultivate until well started.
VI	New Pastures.	Timothy 6#, Ky. blue grass 6#, alfalfa 5#, M.R. clover 2#, ladino clover 1#.	600# of 20% phosphate with manure before seeding.	12	7	Diversions Clearing and leveling Stock water development Pasture management.
	Old Pastures (established sod)		600# of 20% phosphate every four years thereafter as top dressing.			
VII	New Woodlands. (field & gully plantings)	Norway spruce, larch, scotch pine, white pine, scotch pine, Norway spruce, Douglas Fir, European larch, Scotch pine, white oak, hard maple, ash, hickory, red oak.				Protection from fire and grazing Pruning—thinning.
	Old Woods.	Norway spruce, white pine.				Protection from fire and grazing. Improvement and harvest cutting.
VIII	Borders & Wildlife Areas.	Filbert, highbush cranberry, bayberry, tatarian honeysuckle.				Wildlife area management—pruning.
	Outlets.	Alfalfa 4#, M.R. clover 3#, ladino 1#, timothy 5#, red top 2#—Alfalfa 5#, M.R. clover 2#, ladino 1#, timothy 6#, Ky. blue greass 6#.	600# 20% phosphate with manure. Top dress with same every four years.	20	7	Mow.
	Road Banks.	Alfalfa 6#, red top 6#, tall oat grass 10#, alsike 4#.	800# of 5-10-5 with manure & well worked in.	20	7	Slope—diversions—contour furrows—structures—mulch—mow or prune.

Figure 1—Conservation Practices and Treatments for Soil Group 1, Schoharie County Soil Conservation District, N. Y.

information for carrying out the practices recommended.

The section with recommendations of practices covers the whole soil conservation program. Figure 1 illustrates the arrangement of the information for Soil Group 1 in the Schoharie County Soil Conservation District, New York. Across the top of the table are three things. The soils in Group 1 are listed. The Group is described telling briefly what can be expected in terms of crop response, the erosion hazard, workability, etc. At the right, a table gives the land-capability classes for the soils in this group on different slopes and affected by various degrees of erosion.

LISTS PRACTICES, TREATMENTS

The main body of the table contains the conservation practices and treatments for each land-capability class on Group 1 soils. In the Schoharie County District, the most intensive use recommended for Class I land is four years of row crops followed by small grain and two years of hay. This is shown in the column "Land Use." The next column to the right shows the seed mixture which can be used for the hay in this rotation. Under the next columns headed "Treatment" are given the recommendations for fertilizer, manure and lime. In the last column are given the supporting practices. These are the practices necessary for continuous safe and productive use of this land if it is desired to follow the rotations given in the column headed "Land Use."

The uses, practices and treatments for each capability class can be followed through in the manner just outlined. In each case, the most intensive rotation or land use suitable for the class is given in the column under "Land Use." For example, if it fits the farm arrangement and economy, pasture may be the thing to use on Class III land instead of a four-year rotation.

The soil conservationist who is using this table starts just a little ahead of the steps outlined above. On his conservation survey map, he reads the soil symbols on the farm and finds the proper soil groups. Once he finds the applicable soil group, he can turn to the correct page in the Guide. Each group of similar soils has its own land capability table and distinct set of practices and treatments.

Soil Conservation Service technicians in the Northeast like their Technical Guides. They say it takes a lot of work to think through and assemble the information in an orderly way. But this process in itself is good in-service training.

MATERIAL IN ONE PLACE

Many have said that the preparation of the Guide has given them a correlation of soil conditions and land capability with the range of land use and supporting practices which they had not previously comprehended. They say, too, that having all the material like capability classes, recommended treatments, and job descriptions in one volume is convenient and time saving.

The Guide is used by old and new employees. The older men use it as a technical reference. New men use it in their training. The result is more coordination of thinking by all technicians in a district. This pays off in more uniform high-caliber work on the land.

Every Technical Guide reflects the standards of work set by the Soil Conservation Service. Thus, where the Guide is available, the technicians have these standards in practical written form available for everyday use.

From the President

WHEN CASON J. CALLOWAY demonstrated by example the need, value, and benefit of diversified farming in the south, he initiated a program on his holdings which needs to be followed in principle on most of the farm land of the nation. Even before the war, and particularly during the period of the conflict and up to the present time, we have and are following exploitive farming methods which can result in only one thing—exhausted soil resources and a weak and decadent agriculture.

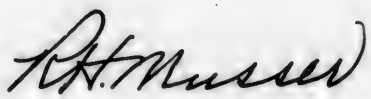
One-crop systems—whether they be cotton, tobacco, wheat, corn, soy beans or similar crops —are not good for the land. But still of greater significance, they're not good for the people living on the land. Considering the past two depressions and adverse climatic cycles, it is not improbable that agriculture may again be forced to retreat and accompanying such a movement will be all the human misery that is bound to follow in its wake.

We have the results on every hand of diversified and conservation farming resulting in increased yields of all types of crops. Retention of soil and water on the land and fertility in the soil, where it belongs, is a reality. Longer farm leases between land owner and tenant result in not only better relationships but also in a greater appreciation of the land by both. Healthier bodies, more nutritious food, and fertile soil all go hand in hand.

In this connection it is interesting to note recent experimental data from the soil experiment fields at the University of Illinois. Corn grown on land with a good legume rotation and soil treatment contained 600 pounds of protein in 100 bushels of grain. The same variety of corn from land with a poor rotation and no soil treatment contained only 380 pounds of protein in 100 bushels of grain—a difference of 220 pounds of protein. In the one example the grain produced had over 10% protein—the other less than 7%.

We simply cannot afford to continue exploitive land practices. Or perhaps it could be better said that we can afford to practice only conservation farming and use a diversity of crops which is an integral part of the conservation way of using land. In addition to the benefits I have already referred to, the big pay-off is providing for sustained productivity of fibers and nutritious food and the permanent use of the land—for now and for the future.

Obviously the Society has a vital interest in diversified farming—it is hitting at the very core of our objectives. In our various professional capacities we can contribute to the principles supporting diversity of land use. As a Society we should give full consideration in charting a course which will give more recognition to good conservation farming practices. It should warrant our combined efforts of an ever-increasing application of conservation on the land.



Notes and Communications

A Modification in Land Classes Is Suggested by Conservationist

Taxonomists have a difficult task. Theirs is the job of seeing that things are classified according to a readily identifiable system. They succeed to the extent that they can make their case on logical and sound grounds. When a classified object or group of objects are not too well described, confusion occurs. This may be derived from a number of causes such as an inadequate basis of classification, lack of sufficient evidence, unfamiliarity with the object, etc. This is as true of the taxonomy of land as of plants or animals. And agreement in classification calls for a consideration of known facts, sharp definition, a scientific approach, and an understanding of the subject matter.

The taxonomy of land as suggested by Mr. Hockensmith in his "The Scientific Basis for Conservation Farming" needs such a study in order to achieve agreement and adoption by conservationists. His proposed capability classification may be sound from the standpoint of the agricultural specialists and farmer advisors as to the "Land Suited for Cultivation." When the author attempts with the same advice to classify all lands he is in trouble. As a conservationist with some experience with the types listed as "Land Not Suited for Cultivation," it is suggested that ideas from other groups are needed to provide a workable classification. In this group should be of course soils men, geologists, foresters, range men, and those experienced in large scale enterprise on non-farm lands.

First, let us look at the classification proposed. Class V land is "good land for grass or trees" because among other things, "it is wet." Wet land is not "good land for grasses or trees." Class VI land is "suited for forestry or grazing; needs protection measures." Although the legend for Figure 6 states that "this land is subject to very severe erosion" many conservationists cannot agree that cattle grazing is a protective measure for critical land. Because this land when in trees is subject to minor limitations, it may be the area where the author believes the bulk of forest lands belongs. Class VII land can be used for forestry or grazing with major limitations. It differs from VI apparently only in that it is steeper and rougher. Class VIII is "suited only for wildlife or recreation." This can of itself be understood but when it is illustrated as in Figure 8, one's ideas of wildlife habitats and recreational areas suffer from shock. Man should have some outdoor recreation. This he usually finds along a watercourse or body of water, not in dry, sun-baked and barren lands. How such land can be of special importance for soil and water conservation re-

Conservationists Note

If you are a county agricultural agent, a forester, or a farm planner and have learned something that makes your work easier or more effective, why not write it up and send it to the Editor of the JOURNAL? The chief purpose of the JOURNAL is to serve the members of the Society. The articles included should be *useful.* Things you are learning as practising soil conservationists can be very useful to other members of the Society. What you write need not be a fancy article, or long. Just tell in plain terms what you have run across or developed that helps you do a better job. Remember that we can use illustrations — drawings or photographs. If every member will share with others the tricks of the trade he is learning, the JOURNAL can become a more valuable publication and we can all share in the growth of the profession for which the Soil Conservation Society of America stands.

quires much imagination. How such land can be ideal for recreation or suited to wildlife is at least questionable.

These descriptions and their illustrations are followed by Figure 9 presented to show seven of the eight classes. Class VIII in the background looks to the forester conservationist as excellent Class VI land. Certainly it ought not to be in VIII or there would be no need of forest conservationists in America.

From a forester's point of view, a different classification of the non-cultivable lands is necessary. Suggested for discussion by the Society are the following:

V. Suited for grazing or forestry; needs ordinary good management. Land nearly level and subject only to slight sheet erosion. Not suited for cultivation because too wet, rocky, saline, subject to overflow, or has some other drawback. Most such land will grow some form of grass, browse, or trees.

VI. Suited for grazing or forestry; needs ordinary good management. Land not suited to cultivation. Moderately sloping land, not flood producing or subject to erosion unless cover is abused or soil exposed. Fencing, watering facilities and salt, and limited or controlled grazing needed on grass lands. Stock not permitted in hardwood forests or in erosive areas. Contour furrows, ridges, and water spreaders may be needed in grass lands to protect the land and increase production.

VII. Suited for grazing or forestry; needs high type of grazing or forestry management to prevent erosion or rapid run-off. Usually rough or steep slopes, or potential ar actual flood and silt source areas. Protection and management to be intensified as climatic or soil conditions worsen.

VIII. Suited for watershed protection purposes only. Critical forest or grassland areas requiring intensive management and protection to insure only such use as will maintain good land conditions and not endanger the soil or water resource or create hazardous conditions downstream.

IX. Lands not otherwise classified as barren land above timber line or in deserts.

Furthermore, and as a gratuitous suggestion even for lands that are or can be cultivated, the forester conservationist would add to Class II, the use of shelterbelts as a guard against wind erosion.

This statement was submitted by E. N. Munns of the Division of Forest Influences, Forest Service, Washington, D. C., in reply to an article by R. D. Hockensmith, entitled "The Scientific Basis for Conservation Farming," that appeared in the April issue of the JOURNAL. *It is hoped that others will express their viewpoints regarding this important subject.*—EDITOR.

Texans Are Recognized By Fort Worth Chapter

The Fort Worth chapter of the Soil Conservation Society of America had a hand this year in giving recognition to Texas farmers and business men who contributed the greatest share to the soil conservation movement in 1946.

Bronze plaques designed by the society and provided through contributions by chapter members went to non-farmers credited with making the greatest unselfish contribution to soil conservation in each of the five sub-divisions into which the Texas soil conservation districts law provides the Lone Star State for administrative purposes.

The plaque presentations were part of the $10,000 *"Save the Soil and Save Texas"* achievement program conducted by the Fort Worth Press. State awards for outstanding conservation achievement by individuals, groups and districts were presented to winners at a banquet in Forth Worth May 10. Winners in one of the state sub-divisions also received their awards at the banquet. Dr. H. H. Bennett, founder of the society and chief of the U. S. Soil Conservation Service, was the principal speaker. Paul Gillett, chapter president, presented the plaque that was awarded at the banquet.

Awards in the other four sub-divisions were

(*Continued on page* 170)

BOOK REVIEWS

THE RUFFED GROUSE. By Frank C. Edminster. New York. The Macmillan Company. xxvi + 385 pp., 17 figs., 56pls., 12 tables. 1947. $5.00.

THIS VOLUME brings under one cover the pertinent information on the most important game bird of the forests of North America. The story of its life, ecology, and management is of major interest to sportsmen, woodsmen, and conservationists. The author is Regional Biologist for the Soil Conservation Service in the northeastern part of the United States. He has been a student of this woodland bird for over sixteen years, and has an intimate knowledge of its relations to soil and land. His writing is "crisp" and readable. All but the most technical parts may be read as a story, and the most scientific chapters show a clarity of thought that makes their reading a pleasure. The book is divided into three parts—Its Life Story, Ecology of the Ruffed Grouse, and Management of the Ruffed Grouse.

The intimate life story of a young hen bird is told in Chapter 3 under the title "Biography." The thirty-two pages of this chapter are packed with grouse thoughts and woods-lore that will leave the reader with a sympathetic understanding of the northern forest. Woven into this chapter are facts about the year long activities of the bird. Hunters of grouse who know only of the fall conditions and life of this bird will find here a fascinating supplement.

Not only in this chapter, but in other parts of the book, the author shows the refreshing quality of his attitudes and his hopes for conservation of the grouse habitat. His enthusiasm for the application of constructive and vigorous methods of forest, water, and soil conservation is of the most positive kind. Practical methods of land management that will benefit the grouse woods as well as the rest of the land—regardless of use—are set out in bold figures and pointed description.

Other subjects of special interest to lovers of grouse and the land are chapters on Food and Water, Man's Relation to the Grouse, and Management of the Ruffed Grouse. Anyone wishing to delve into a study of parasites and diseases or the effects of weather conditions or predation will find chapters on these subjects. Productivity and population cycles are clearly analyzed. The reviewer knows of no place in the literature where carrying capacity and saturation point are so well discussed.

Probably the most useful part of the book for the land manager is the part on Management. It is literally packed with ideas and methods on extensive and intensive management, on the improvement of woodland cover, specific plans for seeding, planting, and laying out areas of land for grouse habitat development. The establishment of borders, clearings, drumming and nesting sites, and the patterns necessary to successful harvest of the bird crop during years of abundance and protection of the breeding stock during the low of the cycle are discussed.

For anyone interested in going further in their study of the ruffed grouse, Mr. Edminster has listed selected references at the ends of each chapter. His selection of photographs is excellent and they do what illustrations are supposed to do—set forth specific ideas that supplement the text. Line cuts, especially, give the book an artistic touch that is very pleasing.

The Ruffed Grouse is recommended without reservation. It is a contribution of outstanding value to foresters, soil conservationists, wildlife managers, and sportsmen who have a true interest in nature. It will undoubtedly be the outstanding wildlife book of the year.

—WARREN W. CHASE

LAND FOR THE FAMILY. By A. F. Gustafson, E. V. Hardenburg, E. Y. Smith, and Jeanette B. McCay, Comstock Publishing Company, Ithaca, New York. 501 pages. 1947. $4.00.

ANOTHER FINE contribution to the popular literature on American farming has come

from the pens of Cornell's agricultural faculty. In "Land for the Family," four authors have collaborated to provide a comprehensive story of living with plants and animals on the farm.

The authors place great emphasis on developing the farm as a home in the country, as indicated by the book's subtitle, "A Guide to Country Living." They start by giving suggestions on selection of a desirable community for the farm home, and for placing the home itself. Cultural facilities available are important as well as having productive soils. Methods of handling the soil, including prevention of erosion and appropriate types of farm machinery come next.

Most of the space is devoted to the selection of crops to grow and the techniques of growing them. While there is ample information on crops grown commercially, the main attention is given to producing food for the family. Since only 13 percent of farm families grow enough potatoes for their own use, only 10 percent enough green vegetables, and even lower proportions for other vegetables and fruits, this is a subject deserving wide attention.

The vegetable garden, home fruits, feed crops, and flowers and ornamentals each have their chapters. Then follow discussions of poultry, dairy, honey, and meat products. Woodlands and wildlife are given brief treatment.

The final six chapters cover food problems in the home. Arrangement of kitchen facilities, balanced diets, and all the modern methods of preserving and storing foods are fully treated.

The book is well-illustrated with many photographs, and has 55 tables of useful facts about foods.

While recognizing that the main theme of the story is food, the text could be improved by a somewhat fuller treatment of the farm's woodland crops, its wildlife, and opportunities for recreation through hunting, fishing, nature study and outdoor sports.

FRANK C. EDMINSTER

SOIL AND STEEL. By P. Alston Waring and Clniton S. Golden. Harper and Brothers, New York. 1947. $3.00.

SOIL AND STEEL, as you might suspect, is about farmers and industrial wage earners who together make up about 85 percent of our population.

The theme of *Soil And Steel* can be best expressed by a paragraph from the superbly written first chapter, which in effect is a condensation of the entire book: "Within the groups in which we live as a farmer and a wage earner, and between them, we know there is a cleavage and that this cleavage constitutes a threat. But equally there is present a wide basis for renewal of common understanding and common action."

Mr. Waring, farmer, and Mr. Golden, union leader, have probed deep into farm-labor relations. They know what they want to say, and they say it well—often sharply but never angrily. Indeed, the authors show admirable restraint in discussing points about which they obviously feel very strongly.

For instance, they say that the Farm Bloc in its present role is a force for cleavage. "As the technology of production has advanced, and as there has grown up a vast nonfarming group of business concerned with processing and distributing food, a coalition has developed of the upper third in agriculture and these nonfarming related groups which seeks its own self-interest at the expense of other farmers." Further: "The Farm Bloc-Big Business coalition is interested in driving out of agriculture large numbers of the less highly productive family-farmers."

Under a sub-chapter heading, "Climate of Peril," the authors bluntly say "divisionist tactics of those who for economic gain drive wedges between groups in society can lead only to the erosion of that unity which is our chief security against fascism." Further: "Those people interested in a free America might well ask to what extent the rural press is dominated by nonrural interests. They might rightly want to know how much the misunderstandings between farmers and wage earners are being en-

Announcing the

GOODYEAR

Soil Conservation Awards

for governing bodies of soil conservation districts and for cooperating farmers.

The following excerpts are from an announcement folder now being distributed by The Goodyear Tire & Rubber Company, Inc., Akron, Ohio.

GENERAL. This program makes no attempt to start anything new—merely aims to recognize outstanding accomplishment by Soil Conservation Districts in their normal work—.

WHEN AND WHERE. Awards for accomplishment from July 1, 1947 to June 30, 1948 in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin (U. S. Soil Conservation Region No. 3)—may be continued and extended in subsequent years.

CHOICE OF WINNING District in each state made by a state committee using a uniform point-system score-card.

When submitting score-cards Districts will designate three cooperating farmers selected for outstanding performance—.

LOCAL AWARDS. Handsome bronze plaques to each member of governing body of Soil Conservation District winning top recognition in each state, and to the three winning farmers in that District.

Secondary plaques to the "runner-up" District in each state.

A Certificate of Meritorious Achievement to the three farmers designated in each District participating in program.

Presentation of plaques will be made at dinner celebrations held in winning Districts with attendance of prominent state officials and educators in agriculture—a state-wide testimonial to the best Soil Conservation District in the state preceded by a brief tour of local soil conservation projects.

Local community organizations will handle these dinners thus keeping the celebration local and bringing in guests to pay honor where honor is due.

ARIZONA TRIP AWARD. All members of governing body of winning District in each state will be invited by Goodyear for a week's vacation trip to Goodyear Farms, Arizona, in November 1948. The three winning farmers from the winning District in each state will select one of their group to accompany the governing body on the Arizona trip.

Expenses of Goodyear's guests on this trip will be paid from home localities to central meeting point, thence by special car to Arizona's winter sunshine, and return.

CONSOLATION PRIZES in this program are unusual—of far greater value than awards to winners—the consolation of knowing that every hour, every ounce of energy devoted to Conservation during the specified period is of untold benefit to a healthy, continuing American Agriculture.

GOODYEAR

larged and played upon by forces which would gain as a result of a widened cleavage between these two important groups of American citizens." Here the authors name names and instances. In fact, one episode involving a major strike and the activities of "Big Business" through the rural press, is documented.

The authors are at their best in probing into the cleavage between farmer and laborer, and its causes and effects. They deal effectively with why farmers and workers "are like that"; what they want from education; how they feel about public policy, surpluses, full-employment.

Understandably, however, Messrs. Waring and Golden do not have too much to offer on the latter part of their theme: the opportunities that exist in present-day society to narrow the breach between farmer and worker. They say that "on the American highway of today the two-way traffic between town and country is creating a new society," but admit "no new society has come to birth without struggle and without conflict."

Under "Techniques for Unity" they discuss several devices they say will bring about greater understanding. Among them are the co-operatives, the soil conservation districts, the TVA and similar regional developments of river valleys, county and local farm committees, joint production committees, collective bargaining, extension of social security, rural electrification, improved public health and sanitation, conferences of farm and labor people. "Little by little, techniques are being forged to unite, on a better plane of understanding, the working people of town and country."

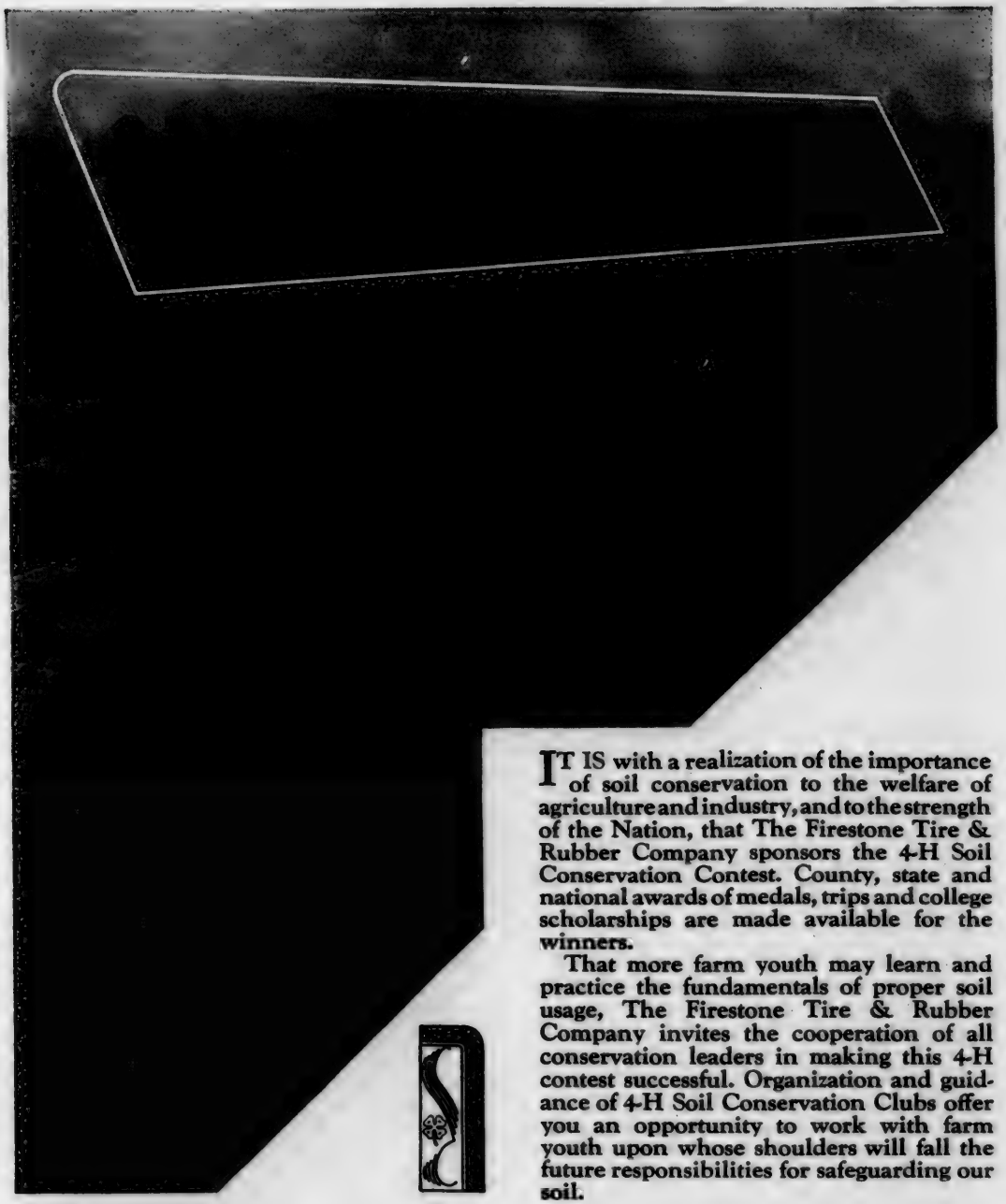
The soil conservation district is called "the most exciting development in local democratic government that has appeared in many a day . . . it has given rural people a new way to work together and with others for their own good and for the benefit of the community . . . its emergence in rural America is a kind of cultural revolution, and a clue to its vital social strength lies in the way it combines formal and responsible popular government with a competent technical service, a kind of marriage of the people and the experts in a scientific age."

The professional soil conservationist may find these statements a bit hard to reconcile with the authors' ideas about TVA, which is lauded as "grass-roots democracy" where great work has been done to check erosion and related land-use problems. Regardless of the overall merits of TVA (and this is no place to become involved in *that* argument) it is a fact that very little has been accomplished there in the basic soil conservation work professional soil conservationists espouse.

The PAC and the Farmers Union will find in *Soil And Steel* a book of great value. Others may shudder and call it "radical." The objective reviewer will find it a readable and enlightening study of an important issue of our time, regardless of whether or not he agrees with the authors in toto. Hardly anyone, however, can disagree with Farmer Waring and Labor Leader Golden when they say:

"Farmers want a chance to produce without the fear of surplus. They want security of tenure and opportunity for education and some of the cultural amenities of life which they see existing in modern cities. Wage earning people want a chance to work freed from the fear of unemployment. They want a decent home, wages commensurate with the cost of living and a sense of belonging not only on the job but in America. . . . Here are revolutionary demands which farmers and workers alike are making. And they require basic answers. . . . Some of the leadership will come from among the people who live on our farms and who make the products of our factories. . . . We are sure that if we raise our sights to matters of the general welfare many petty differences which now exist among farmers and wage earners will melt away."

—HAL JENKINS



IT IS with a realization of the importance of soil conservation to the welfare of agriculture and industry, and to the strength of the Nation, that The Firestone Tire & Rubber Company sponsors the 4-H Soil Conservation Contest. County, state and national awards of medals, trips and college scholarships are made available for the winners.

That more farm youth may learn and practice the fundamentals of proper soil usage, The Firestone Tire & Rubber Company invites the cooperation of all conservation leaders in making this 4-H contest successful. Organization and guidance of 4-H Soil Conservation Clubs offer you an opportunity to work with farm youth upon whose shoulders will fall the future responsibilities for safeguarding our soil.

Firestone

Copyright, 1947, The Firestone Tire & Rubber Co.

AKRON OHIO · MEMPHIS TENNESSEE · LOS ANGELES CALIFORNIA

Listen to the Voice of Firestone every Monday evening over NBC

THE FURROW AND US. By Walter Thomas Jack. Dorrance and Company, Philadelphia. 158 pp. 1946. $2.00.

INSIDE THE FRONT of the paper jacket that comes with this book the publishers say, "*The Furrow and Us* is the answer to *Plowman's Folly.*"

Perhaps their statement will help sell more copies to people who have read and heard about Plowman's Folly but it seems to me it is underestimating the power of the book a little. Mr. Jack is no mere counter-puncher. He possesses a philosophy of soil and man that is more important than any mere rebuttal of another man's book. If you are going to read the Furrow in hopes of running across an extensive display of verbal fireworks, you had better pick up something else instead.

The author does make a few tentative passes at Faulkner in the early pages of his book but they seem to be for effect, mostly. Actually, when you balance the two books, both men are conservationists who would take care of America's soil wealth—or rather, have farmers do it. The only difference between their outlook is that Jack, the Iowa farmer, knows more about the soil and the practical process of making it grow food than does Faulkner, the backyard experimenter. Faulkner thinks the plow is used not wisely but too well. Jack, on page 78 and 79 of his book, says, "If the Plowman has a serious folly, it is the time he plows, not the act of plowing. . . .".

To hew closer to the core of it, Mr. Jack's book might better be described as the story of soil and life as it is understood by a very intelligent man who has worked with soil and studied it all his life. The author is a farmer, not a soils man or agronomist, but he knows how to express what he has seen and learned—and what others have learned, too.

Whether or not all of his conclusions are correct, each reader will have to decide for himself but Jack has some pretty impressive data to back up most of what he says, even without literary footnotes. He treats the history of soil and agriculture, soil relationships, soil and nutrition, soil and crop management and a number of other complex subjects in various chapters. Maybe a book of 158 pages has to oversimplify to get all this within its covers and probably the Furrow will never become a classical treatise on any of its various subjects. But, a lot of thoughtful people who read it will find that the author has straightened out some difficult ideas and given them a more complete picture of soil and man than anyone else has done in such a short space.

The book is not listed as entertainment, however.

—BUCKLEY MAITS

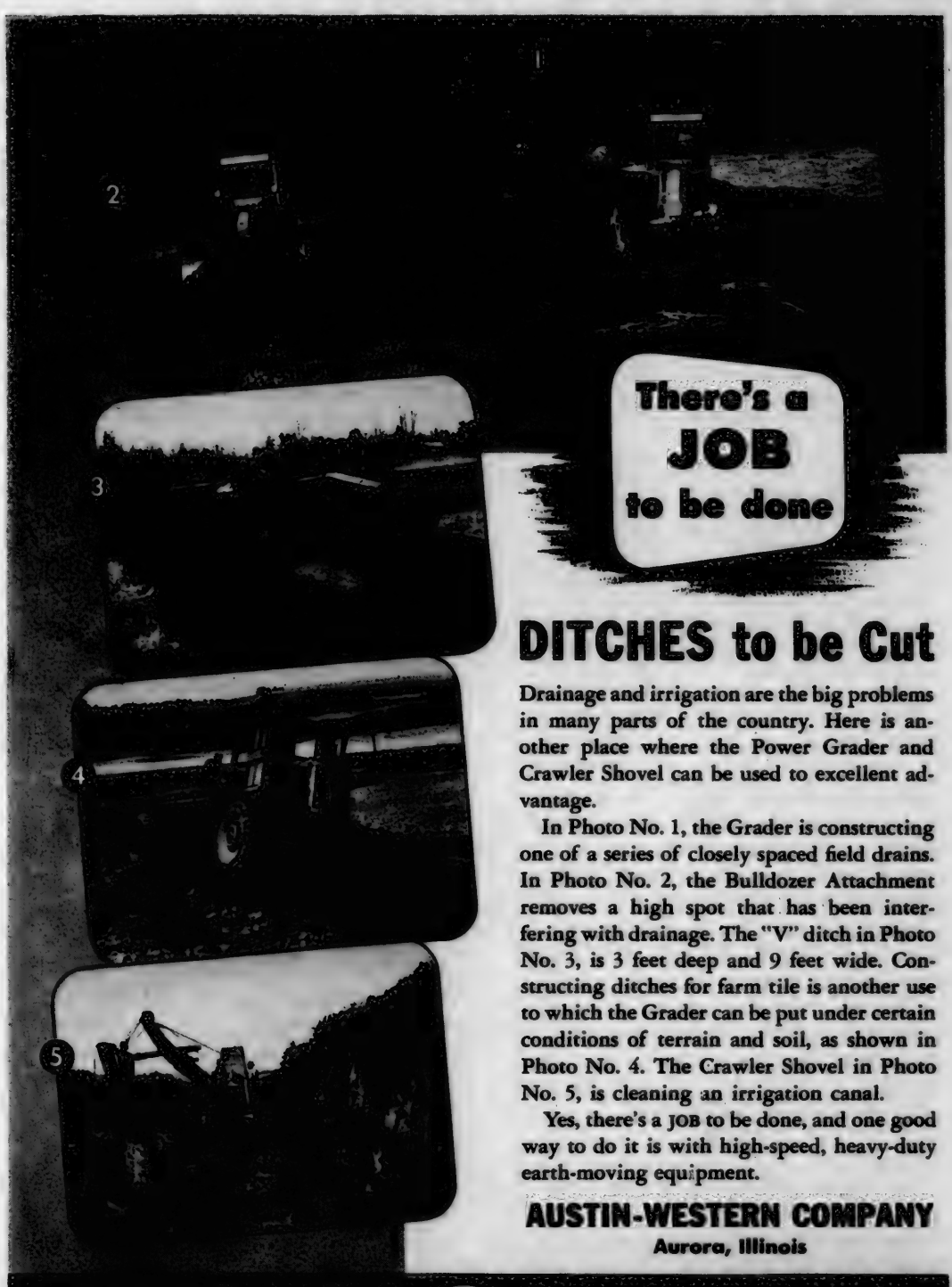
New Books Received

Some of the books listed in this section are to be reviewed in future issues of the JOURNAL. An effort will be made to cover all fields of conservation from time to time in so far as complete reviews are concerned.

SOIL AND CIVILIZATION. Elyne Mitchell. Angus and Robertson, Ltd., Sydney, Australia. 141 pages. 1946. 4s 6d. This is a significant book. It presents a belief: a philosophy gleaned from the history of ancient civilizations, and a belief in the mystic affinity of a people with the soil and the seasons as their life. It should be read by every conservationist.

ONE HUNDRED YEARS IN YOSEMITE by Carl P. Russell is an account of the men who helped to develop this great national park from an unknown wilderness. University of California Press, Berkeley. 1947. 226 pages. $3.75.

THE LAZY GARDENER. This book by William C. Pryor is packed with practical information for the part time gardener. It is written in a leisurely, gentle and amusing style and is packed with practical information. Even the drawings provide an atmosphere of lazy gardening. Longmans Green and Company, New York. 1947. 226 pages. $3.00.



There's a **JOB** to be done

DITCHES to be Cut

Drainage and irrigation are the big problems in many parts of the country. Here is another place where the Power Grader and Crawler Shovel can be used to excellent advantage.

In Photo No. 1, the Grader is constructing one of a series of closely spaced field drains. In Photo No. 2, the Bulldozer Attachment removes a high spot that has been interfering with drainage. The "V" ditch in Photo No. 3, is 3 feet deep and 9 feet wide. Constructing ditches for farm tile is another use to which the Grader can be put under certain conditions of terrain and soil, as shown in Photo No. 4. The Crawler Shovel in Photo No. 5, is cleaning an irrigation canal.

Yes, there's a JOB to be done, and one good way to do it is with high-speed, heavy-duty earth-moving equipment.

AUSTIN-WESTERN COMPANY
Aurora, Illinois

BUILDERS OF ROAD MACHINERY

Austin Western

SINCE 1859

Recent Research Reviews

J. H. STALLINGS

Recent Research Reviews by J. H. Stallings is a new feature in the JOURNAL. It is hoped that the projects reviewed from time to time will be helpful to conservationists everywhere. Members of the Society are urged to indicate their interest in the kind of research work that should be reviewed.

A METHOD FOR DETERMINING THE USE AND LIMITATIONS OF ROTATIONS AND CONSERVATION PRACTICES IN THE CONTROL OF SOIL EROSION IN IOWA. By G. M. Browning, C. L. Parish and John Glass, in cooperation with the Iowa Agricultural Experiment Station. Journal American Society of Agronomy, Volume 39, No. 1, pp. 65-73, January, 1947.

The purpose of this paper was to bring together detailed, specific information on the Marshall, Shelby, and Fayette, Soils and develop from these data certain principles that may possibly be used in combination with all other available data in preparing recommendations on other soil types in Iowa on which detailed, specific data are not available. Using specific data from the Fayette, Shelby and Marshall soils as found on the La Crosse, Wisconsin, Bethany, Missouri and Clarinda, Iowa Stations as a guide and from observation and physical and chemical properties available on related soils on which soil and water loss data are not available, a guide was developed for all soils mapped in Iowa, showing the use and limitations of rotation and conservation practices in the control of soil erosion.

BOBWHITES THRIVE ON BICOLOR. By Verne Davison, USDA-SCS, Soil Conservation, Volume XII, No. 5, pp. 99-100. December, 1946.

Soil conservation farming supports bobwhite quail better than either nature or man has been able to do before. Thousands of bobwhites are feeding in strips of bicolor lespedeza this winter. With the use of bicolor come some new ideas—new principles in land management for game.

Quail begin to feed on bicolor seed in late October, use it regularly every day, returning for its daily sustenance until insects are in dependable supply next spring. It has stood tests of preferences against every recognized food in the field. It is more dependable than any other. Its range of soil adaptability, though not completely known, appears to be wider than any other single quail-food plant. Being perennial, it is more economical than annuals, for once established, it is not expensive to manage.

REVEGETATION OF ERODED LANDS IN THE HIGH PLAINS AND ROLLING PLAINS OF TEXAS AND OKLAHOMA. By W. M. Nixon. Soil Science Society of America. 1946.

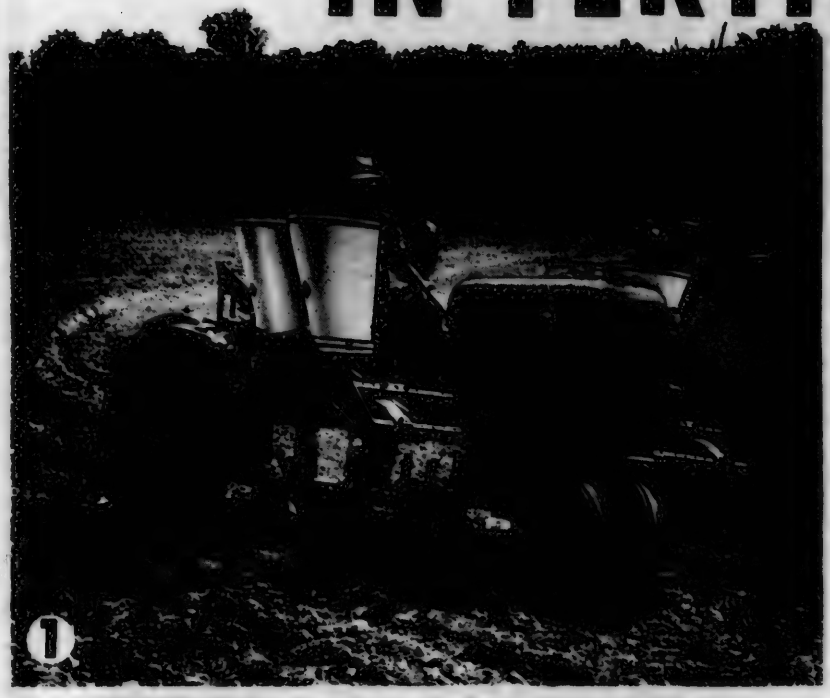
The revegetating of eroded crop land constitutes a major phase of the coordinated soil and moisture conservation program.

Thousands of acres of land in the area are not suited for cultivation, and should be returned to a permanent cover of grass. These areas are not adapted for cultivation because of soil characteristics or topography.

Typical examples are deep, shifting sands; shallow soils; and steep, eroded areas. Wind and water erosion are common to the High Plains and Rolling plains. Experience on experiment stations, Soil Conservation Service Demonstration Projects and nurseries, and on the farms and ranches of soil conservation district cooperators during the past 10 years has resulted in the development of sound methods and techniques for establishing grass on such land.

Early work included a comparison of the effectiveness of various tillage methods and cover crops for stabilizing land to be revege-

There's FUTURE IN FERTILITY



THREE METHODS... SAME INTERCHANGEABLE HOPPERS

Applying fertilizer while plowing, seeding and cultivating eliminates extra operation. Precision placement requires less fertilizer, produces bigger yields. Interchangeable hoppers reduce equipment overhead. Use all three methods for maximum results.

1 PLANTING — Fertilize while you plant. Greatest return from small amount of fertilizer. Stimulates early plant growth. Young crops grow faster than weeds — mature earlier.

2 PLOW-SOLE — Fertilize while you plow. Makes plant food available to deep growing roots and sub-surface moisture. Produces impressive yields. Can be applied fall or spring. Fertilizer immediately covered — no waste. Especially desirable for corn and deep-rooted crops. Heavy applications possible without danger to plants.

3 SIDE DRESSING — Fertilize while you cultivate. Provides plant food when greatly needed; places it in area of greatest advantage to plant. Requires half as much fertilizer as when broadcast or disced in. Convenient method for applying extra applications to thin soils.

ALLIS-CHALMERS
TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

Your Booster . . . The NATIONAL FARM and HOME HOUR with Everett Mitchell
EVERY SATURDAY • EVERY NBC STATION

tated, and providing non-competitive cover in which to seed grasses. It also included the evaluation of species, mixtures, seeding rates, dates, and methods of seeding.

Revegetation work has progressed to where more than 80 percent of seedings are successful. Thousands of acres are being established annually. Factors determining the successful establishment of grasses are listed.

Sufficient amounts of seeds and seeding equipment are the major limiting factors in revegetation work. However, widespread interest of farmers, ranchers, agricultural workers, seed producers, processors, dealers and equipment companies indicate that these needs will be met.

DYNAMICS OF WIND EROSION. By W. S. Chepil, Canadian Department of Agriculture. Soil Science, Volume 60, No. 4, pp. 305-370, October, 1945.

There are, according to Mr. Chepil, three types of movement of soil caused by the action of wind, namely, saltation, suspension and surface creep.

The largest portion of the soil carried by wind is moved in a series of short bounces called "saltation."

Particles smaller than 0.1 mm. in diameter have a velocity far lower than the upward velocity of the turbulent wind. Such particles are carried more or less parallel with the general direction of the wind, and form what has been termed "suspension movement."

"Surface creep" consists of rolling and sliding along the surface of the ground of quartz grains larger than about 0.5 mm. in diameter and smaller than 1 mm. which are too heavy to be transported through the air.

After being rolled over the surface by the wind, the particles suddenly leap almost vertically to form the initial stage of the movement in saltation. Some grains rise only a short distance, while others leap one foot or more depending directly on the initial velocity of rise from the ground. They also gain considerable forward movement from the pressure of the wind acting upon them, and acceleration of horizontal velocity continues from the time the grains begin to rise to the time they strike the ground.

The vertical rise of particles in saltation appears to be due to two causes, the spinning of the grains and the steep velocity gradient near the ground. Grains carried in saltation may rotate at a speed of 200 to 1,000 revolutions per second. Perhaps more than 75 percent of the grains carried by saltation spin. Movement in suspension and in surface creep is a result of movement in saltation. The whole program of wind erosion control should therefore depend on methods designed to reduce or eliminate saltation.

EDITORIAL

(Continued from page 122)

tion, necessary to insure maintenance of the land's productivity under the indicated use. Here is a point where soil conservation science is, to a pronounced degree, a systematized synthesis of a number of more specialized sciences.

Fifth, there is an appraisal of the probable effect of the indicated land use and land treatment on adjoining acres and on other land and water in the watershed. If the probable effect is an undesirable one, and this would be abnormal, corrective changes in the indicated land use and land treatment are in order.

Sixth, there is the actual application, based on the foregoing steps. Here again—assuming for illustrative purposes, the construction of terraces, the development of a grassed waterway, contour strip cropping, and the planting of an herbaceous field border on the acre—other specialized sciences are systematically synthesized and unified to become, in fact, part of applied soil conservation science.

The science of soil conservation, therefore, is the accumulated knowledge, including facts, principles, and methods, whereby the productivity of soil and water resources can be sustained indefinitely under maximum, desirable use.

A Cub in Size . . .
but a BEAR for Work!

. . . and Now—

INTERNATIONAL HARVESTER PRESENTS

THE Farmall Cub!

- **For all operations on farms of 40 crop acres or less—and truck gardens.**
- **For special operations on truck farms.**
- **For large farms that need an extra tractor.**

That's the Farmall Cub, the first tractor in history that's *built right* and *priced right* for a great new group of tractor owners.

The Cub is the newest member of the famous FARMALL FAMILY. It brings the advantages of the FARMALL* SYSTEM OF FARMING to the small, family farm.

It's a Cub in size, but "a BEAR for work." You get *big*-Farmall quality and design, plus scaled-down, small-tractor economy. And there is a full line of matched, quick-change, easy-to-control implements.

The smooth-running 4-cylinder engine develops approximately 9¼ h.p. on the belt. It uses considerably less than a gallon of gasoline an hour. There's a comfortable, roomy seat . . . ample crop clearance under the chassis . . . and "Culti-Vision" to give a clear, unobstructed view of your work.

The Farmall Cub, like all Farmall Tractors, adapts itself to approved soil conservation practices. See it as soon as we can get one to the nearest International Harvester dealer. Climb in the seat and drive it.

INTERNATIONAL HARVESTER COMPANY
180 North Michigan Avenue Chicago 1, Illinois

*Registered trade-mark.
ONLY International Harvester builds FARMALL Tractors.

$545 f. o. b. factory
(Equipped as illustrated, slightly higher)
Attachments and implements extra

Hear James Melton on "Harvest of Stars"
Every Sunday NBC Network.

INTERNATIONAL HARVESTER

EVALUATION IN WATER EROSION

(*Continued from page* 138)

16. Neal, Jesse H. The effect of the degree of slope and rainfall characteristics on runoff and soil erosion. Agr. Expt. Sta. Res. Bul. 280. 47 pp. illus. April 1938.

17. Pope, J. B., James C. Archer, P. R. Johnson, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded sandy clay lands of Texas, Arkansas, and Louisiana at the Conservation Experiment Station, Tyler, Texas. USDA Tech. Bul. 916. 76 pp. illus. June 1946.

18. Smith, D. D., D. M. Whitt, Austin W. Zingg, A. G. McCall, and F. G. Bell. Investigations in erosion control and reclamation of eroded Shelby and related soils at the Conservation Experiment Station, Bethany, Missouri. USDA Tech. Bul. No. 883. 175 pp. illus. April 1945.

19. Zingg, Austin W. Degree and length of land slope as it affects soil loss in runoff. An analysis of degree and length of slope data as applied to terracing. Agr. Eng. Vol. 21(2 & 3):11 pp. Feb. and March, 1940.

SOIL MOISTURE RELATIONSHIPS

(*Continued from page* 152)

moved by grazing or by other means, evaporation and runoff rob the soil of part of the available moisture. This leaves insufficient moisture to support all the plants of the climax; some die out. In turn, plants with lower moisture requirements increase. The repetition of this process can result in areas bare of vegetation and finally in destruction of the soil by erosion.

TEXANS ARE RECOGNIZED

(*Continued from page* 158)

presented at later meetings in various parts of Texas.

A brief sketch of the winners of the chapter's plaques follows:

1. G. W. CROSS, editor and publisher of the *Mt. Pleasant Daily Times* and *Mt. Pleasant Weekly Times-Review*, was one of the first in East Texas to recognize the damage being done to the land by erosion. He was among the first to take action. Through his newspapers he informed the people of what was happening on the land, urged them to visit a nearby Soil Conservation Service demonstration project. To be sure they would, he organized and conducted tours to the project himself. He was instrumental in having a second demonstration project begun near Mt. Pleasant. He did yeoman work, through his newspapers and otherwise, in helping to establish the Sulphur-Cypress Soil Conservation District. Though there were no funds from which to pay him, he published the many legal notices and announcements of the district during its formation and organization period. He has continued to be generous in giving newspaper space to the cause of soil conservation.

2. JOHN SHARP of Turkey is a landowner but his primary business is real estate, insurance and loans. He pioneered conservation farming on the land he owns. Organizer of an agricultural club, he took the lead in obtaining equipment needed to do conservation work. When the state enabling act was passed, he sponsored the organization of the Hall County Soil Conservation District. He served as secretary and treasurer from inception of the district until October 1946, missing only eight meetings of supervisors in that period. He has spent freely of his time in helping not only this district, but other districts. When war threatened to close one of the work unit headquarters in his district, he suggested that the one in his own community be discontinued during the emergency. He then assumed the responsibility of continuing the conservation work until the war ended and Soil Conservation Service technicians were again available.

3. HARRY HOLT, agricultural writer of the *Abilene Reporter-News*, has been unceasing in his efforts to get necessary soil conservation practices on the land. Through his daily newspaper column he has given maximum support to soil conservation through district action. Especially interested in seeing the Texas range restored to its former productiveness, he has seen his advocacy of legumes for his area bear

SEND TODAY for this catalog. It lists and describes the movies, booklets, slide films, wall posters, charts, etc., comprising Case "Visual Education Materials." It also tells how to secure supplies of printed items and to schedule the loan of films. Address Educational Division, J. I. Case Co., Racine, Wis.

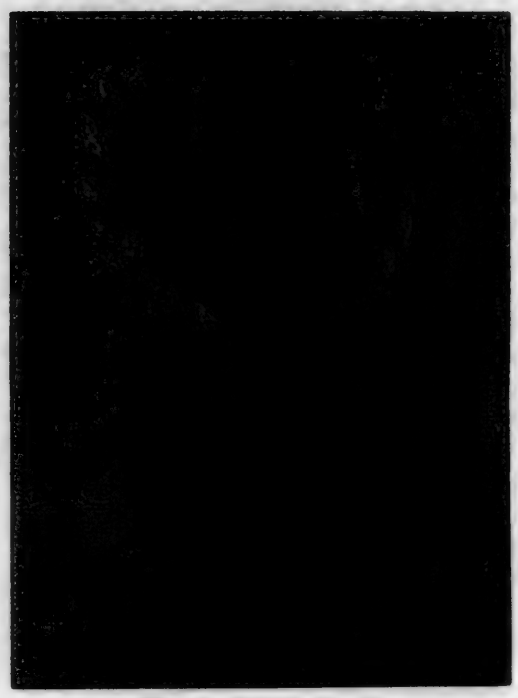
Created to Help You Sell Soil Conservation

● Here are powerful pieces of ammunition for your campaign to push soil conservation beyond the realm of academic acceptance into the living world of everyday farming. They portray conservation with all the dynamic suggestion of actual procedure and tangible results. Because they inspire and instruct farmers in advanced practices with their own farm tractors and implements, they implant the idea of conservation as a way of normal farming.

Titles of a few educational booklets shown above will suggest the scope of Case materials available. Most of them have parallel films of similar title and subject matter. Some are supplemented by wall posters or charts suitable for exhibits at meetings, and for lecture-study use. In all, the purpose is to be simple, clear, vivid.

Case movies on soil conservation and related practices embody tested methods in detail. They are all in the 16 mm. width, in full color and sound. With their companion booklets for detailed study and permanent reference, they provide both initial stimulus and a follow-through. You are invited to use them.

CASE



This is a picture of the bronze plaque designed and presented by the Fort Worth chapter of the Soil Conservation Society of America as prizes in the 1947 Fort Worth Press $10,000 "Save the Soil and Save Texas" achievement awards program.

fruit. While once it was common to hear "they won't grow" "they are not adapted," or "we don't need them," the skeptics can now see thousands of acres of Madrid clover, hairy vetch, Austrian winter peas, hubam clover, alfalfa and crotalaria. The area has gained through these plants and Mr. Holt's efforts to get the farmers and ranchers to use them.

4. EARL T. FAIRMAN, president of the Trent State Bank and owner of the Fairman Company in Goldthwaite, worked for the creation of the Brown-Mills Soil Conservation District. He had been deeply interested in all phases of conservation for several years, his interest stemming from an inherent love of the land and a profound respect for those who manage the soil for a livelihood. When Mr. Fairman learned that certain kinds of scarce machinery were needed to carry on the district's work, he obtained 73 bulldozers for sale to contractors who would build dams, stock ponds and diversion terraces and clear pastures of brush. He procured four graders for building terraces and diversions and six fertilizer grain drills for planting legume cover crops. He lent money to the district supervisors on a non-interest bearing demand note to buy two grain drills. He has obtained large quantities of scarce cover crop seeds and fertilizers for district cooperators at little or no financial gain to himself or his company. He donated a lot in Goldthwaite to the district on which to erect surplus buildings obtained at Camp Bowie. He is personally interested in wildlife conservation as a part of the broader soil conservation program. He has obtained fish for stocking 90 ponds in Mills County. Last year, through his own effort and at his own expense, he propagated, fed and released 1,800 pheasants, 600 quails, and 40 chuckers. His talks with farmers are considered one of his greatest contributions to soil conservation.

5. H. W. McGOLDRICK, vice president of the First Nichols National Bank of Kenedy, has been prominent in advising and helping farmers to turn to conservation farming as a means of saving and improving their land, of increasing the yields and quality of their products, of building up the value of their farms. He takes an active part in the conservation work of the Karnes County Soil Conservation District. In numerous ways he is contributing to the advancement of the soil conservation program in his area.

In addition to plaques, certificates and an all-expense trip to Colorado for the student contributing the state's best essay on soil conservation, $10,000 was distributed as prizes. The money was put up by industrial and mercantile concerns, railroads and Fort Worth banks through their clearing house association. The Kiwanis and Lions clubs contributed certificates, plaques and other prizes.

SOIL CONSERVATION SOCIETY OF AMERICA

CHAPTERS AND THEIR OFFICERS

Washington, D. C.
GEORGE H. PHILLIPS, *Chairman*
J. GORDON STEELE,
Secretary-Treasurer

Portland, Oregon
SAM L. SLOAN, *Chairman*
W. T. WHITE,
Secretary-Treasurer

Huron, South Dakota
DAN E. CASS, *Chairman*
CHARLES O. BROWN,
Secretary-Treasurer

Lincoln, Nebraska
HAROLD ENGSTROM, *Chairman*
ADRIAN C. FOX, *Secretary-Treasurer*

Salina, Kansas
CHARLES R. CURTIS, *Chairman*
WILLIAM H. TEAS,
Secretary-Treasurer

Bozeman, Montana
H. D. HURD, *Chairman*
ERNEST H. SANDBERG,
Secretary-Treasurer

Milwaukee, Wisconsin
SID S. MATHISON, *Chairman*
PAUL J. HENNIG, JR., *Secretary*

William Penn, Philadelphia, Pa.
LLOYD PARTAIN, *Chairman*
J. HOWARD MENDENHALL,
Secretary-Treasurer

Spartanburg, South Carolina
R. L. LESTER, *Chairman*
R. F. HUBER, *Secretary-Treasurer*

Fort Worth, Texas
PAUL T. GILLETT, *Chairman*
HARTZELL C. DEAN,
Secretary-Treasurer

Rio Grande, New Mexico
DEWEY DISMUKE, *Chairman*
VICTOR A. SURFACE, *Secretary*

Inland Empire, Washington-Idaho
WESLEY SPENCER, *Chairman*
C. F. PARROTT, *Secretary-Treasurer*

Empire State, New York
HAROLD E. KLINGAMAN, *Chairman*
R. M. FELLOWS, *Secretary-Treasurer*

San Francisco Bay, California
R. EARLE STORIE, *Chairman*
WAYNE W. AUSTIN,
Secretary-Treasurer

Dick Lewallen, Wyoming
EDGAR A. REEVES, *Temporary Chairman*
EDWARD E. HEDICKE, *Temporary Secretary-Treasurer*

West Virginia State
WALTER C. GUMBEL, *Chairman*
BROOKS DAUGHERTY,
Secretary-Treasurer

Patuxent, Maryland
EDWARD M. DAVIS, *Chairman*
KENNETH M. STONE, *Secretary*

Pocomoke, Maryland
JAMES R. CARROLL, *Temporary Chairman*
FRANK Z. HUTTON, SR.,
Temporary Chairman

Keystone, Pennsylvania
D. E. HESS, *Temporary Chairman*

Southern New England
AYRES BRINSER, *Chairman*
L. T. SMALL, *Treasurer*

New Jersey
LINWOOD L. LEE, *Temporary Chairman*